MISCELLANEOUS PUBLICATIONS
MUSEUM OF ZOOLOGY, UNIVERSITY OF MICHIGAN, NO. 70

# THE LAND AND FRESH-WATER MOLLUSKS OF PUERTO RICO

BY
HENRY VAN DER SCHALIE

ANN ARBOR
UNIVERSITY OF MICHIGAN PRESS
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# THE LAND AND FRESH-WATER MOLLUSKS OF PUERTO RICO

## INTRODUCTION

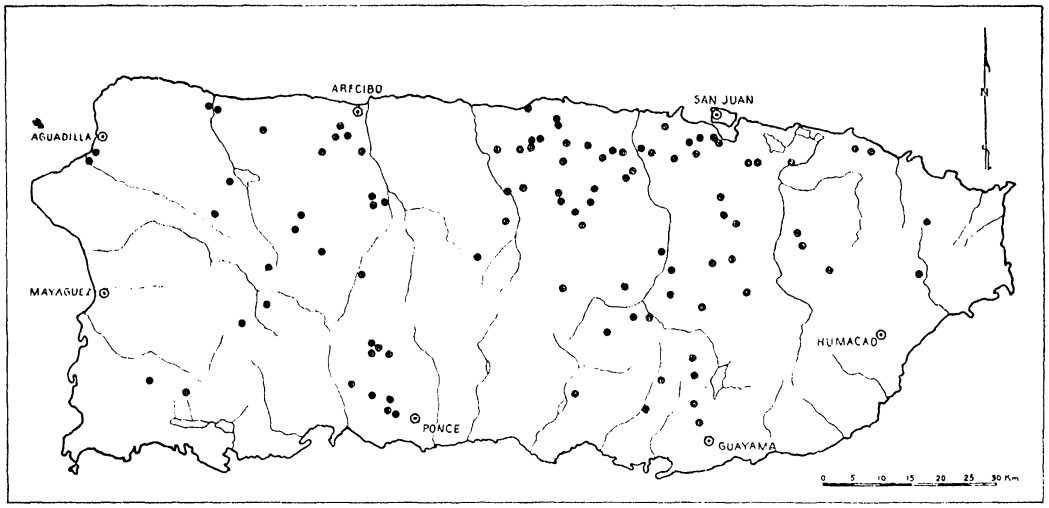
THE following account of the land and fresh-water shells of Puerto Rico is based on collections made in that island during the 1940–1941 school year when I was privileged to enjoy an exchange professorship at the University of Puerto Rico. Holidays and week-end periods were utilized to collect at some hundred widely scattered stations (Map 1). Since the insular government maintains one of the best road systems in the Antilles, it was comparatively easy to travel by automobile to many of the otherwise less accessible parts of the island.

The inland molluscan fauna is rich, consisting of about one hundred and fourteen species of which only about a dozen are fresh-water forms. Land shells constitute the bulk of the assemblage. In the course of the work it became increasingly clear that many problems of necessity would remain unsolved. Much of the early information about the mollusks of this region is in journals available only to those who work in conchological centers. There is, then, a need for an account which will bring together essential data to be used by those not having access to some of the more specialized publications. Whenever possible, comments have been made on controversial problems with the hope that students, particularly those in Puerto Rico, will contribute information to aid in clarifying such issues.

The fresh-water fauna is surprisingly meager. Evidently, this condition has been due both to the geological history of the region and to certain factors now in operation. The rivers of this island are too irregular in nature to support a large molluscan fauna. They often become dry in their headwaters during drouth, and in rainy periods they become violently turbulent, particularly toward their mouths. Also, the intensive program of irrigation carried on in recent years has so altered ecological conditions in many streams that an attempt to collect shells from them is disappointing. Yet, as is generally known, one of the major social and economic problems of the people of this island is centered about the control of one of the fresh-water species, *Australorbis glabratus,* the intermediate host of the blood fluke, *Schistosoma mansoni.* The struggle against schistosomiasis or bilharziasis is closely associated with a knowledge of the habits and distribution of this aquatic snail.

Some land snails have become adapted to the many changes introduced by man, but others exist only in the more inaccessible places. Although several intensive collections have been undertaken, there is ample opportunity for further search in the less disturbed and more sparsely inhabited regions

of the island. There is also a need for studies into the comparative morphology and life histories of many species. H. B. Baker has recently made a number of valuable contributions bearing on the anatomy and phylogenetic relations of several of the larger groups of land shells in Puerto Rico, the West Indies, and Central America.




MAP 1. The stations in Puerto Rico.

ACKNOWLEDGMENTS

I am particularly indebted to the late Dr. F. M. Pagán, of the University of Puerto Rico, who was a continual source of encouragement and aid during the course of the field activities. Mr. Rafael Córdova Márquez, also of the University of Puerto Rico, aided considerably on numerous excursions into the field. Many interesting and profitable discussions were held with Dr. William A. Hoffman, of the School of Tropical Medicine in San Juan, whose sudden death in 1943 was most unfortunate, since he contributed much toward the appreciation of the roles of several snails in life histories of parasites. Dean Julio Garciá-Díaz, of the University of Puerto Rico, was genuinely interested in this work and aided in many ways. In studies of the collections, Dr. H. B. Baker, of the University of Pennsylvania, generously submitted a set of notes based on his field work in Puerto Rico; William J. Clench, of the Museum of Comparative Zoology, Calvin Goodrich, and Aurèle La Rocque, both of the University of Michigan, gave helpful counsel; the late Miss Grace Eager, of the University of Michigan, contributed her expert ability in making the illustrations; and the field work was facilitated and publication was made possible by a grant in aid from the Horace H. Rackham School of Graduate Studies. To these and many others who aided in various ways, I wish to express my grateful appreciation.

## HISTORICAL ACCOUNT

Since the time of Columbus, Puerto Rico has been inhabited and exploited by the white man. Consequently, it is not surprising that a few of the mollusks from this island were among the earliest to be incorporated in the binomial system by pioneers in systematics, such as Linnaeus, Martini and Chemnitz, and Gmelin. Early in the nineteenth century, Férussac[1] (1821–22) and Lamarck (1822) described and listed a few species previously collected on the island by Mauge and Krauss.

The subsequent historical sequence of conchological discoveries is of necessity difficult to reconstruct. The broad outlines are scattered in the literature. Some who may have contributed materially, but whose discoveries have not found their way into print, may have been neglected in general historical reviews. H. Crosse (1892) has given an informative summary of the increase of knowledge of this insular fauna. The main outline of this development is given also, although in less detail, by A. Stahl (1882) and Juan Gundlach (1883).

C. Moritz (1836) mentioned a few land shells that he collected in 1835 during an expedition to the island. He apparently spent about four months collecting mainly entomological specimens for the Royal Museum of Berlin. He visited marginal regions of the north, south, and east coasts; his conchological contributions were meager.

Bernhard Friedrich Blauner, a Swiss naturalist, visited Puerto Rico in 1852. The concentrated effort of this able collector marks the first important stride in gaining an adequate knowledge of the land and fresh-water shells of the island. Blauner was encouraged in his work by R. J. Shuttleworth, who in 1854 published the first list of the mollusks from this island under the title: "Beiträge zur näheren Kenntnis der Land- und Süsswasser-Mollusken der Insel Portorico." Blauner collected mainly in the eastern part of Puerto Rico around San Juan, Humacao, and the region of the Luquillo Mountains. He had planned to continue his careful survey, but after sixteen months of work he fell ill and died at the home of his friend and fellow countryman, Sandoz-Cunier, in Humacao on September 3, 1853. Shuttleworth's catalogue, which enumerated about one hundred species of land and fresh-water shells, has served as a foundation for the more recent lists. This first comprehensive census represents a real monument to the arduous pioneering work of Blauner.

Juan Gundlach explored Puerto Rico in 1874. He was thoroughly familiar with the field activities of his predecessors. Consequently, he made an effort to visit the less known regions of the west. His collections were sent to the Zoological Museum at Berlin, where E. von Martens (1877) studied

[1] A. S. Kennard ("The *Histoire* and *Prodrome* of Férussac," *Proc. Malacol. Soc. London*, 25 [1942]: 12–17) gave proper dates for the many parts of Férussac's works.

and reported on them. Later, Gundlach (1883) published a detailed account of his travels in Puerto Rico. Although he presented the basic information already given by von Martens, there is an observation in Gundlach's article which is of special import particularly, since it is made by one who also did considerable work in Cuba. The following quotation is a translation from Gundlach's (1883) report:

> Even knowing all this, I believed, relying on my experience in Cuba, that one would find many new species in the mountains of the west, a place where I planned to make my main excursions. I believed that, as in Cuba, each region of Puerto Rico would offer to me, mainly among the rocks and rock walls, different species that vary within a short distance, while others would vary within larger areas. But, I was mistaken. Even though I examined many plots of land, I found the same species of land and freshwater shells.

This is an important observation, emphasizing the lack of local endemism in Puerto Rico as compared with that present in Cuba.

Many collectors have contributed to knowledge of the island shells. Among the better-known ones, Sintenis gave a small collection to the German consul, Krug, who sent the specimens to the Berlin Museum, where they were recorded in a short but excellent publication by E. von Martens (1891). Justus Hjalmarson, a pharmacist in Arecibo who collected specimens, is mentioned by Gundlach as having received him cordially when Gundlach visited the island. Mention should be made also of A. Stahl (1882), a naturalist who lived in Bayamon. Although Stahl is better known as a botanist he had sufficiently broad interests to devote a section of his *Catalogo del gabinete zoológico* to mollusks. Other familiar names among the early contributors are: Swift, Riise, Newton, and Knox. These men sent specimens to Pfeiffer, who named some of the species in their honor.

In 1901, Dall and Simpson published a report entitled: "The Mollusca of Porto Rico." This represents the most complete list of the mollusks on this island. They added much new information concerning the marine forms, information contributed largely through the collections made by those who conducted the explorations of the steamer "Fish Hawk." The principal sources of data concerning the land and fresh-water shells are those previously mentioned, so that but little was added to what was already given by Shuttleworth (1854), E. von Martens (1877; 1891), Gundlach (1883), and Crosse (1892).

Since the turn of the century the following investigators have been instrumental in adding materially to the accumulated knowledge about the mollusks of this island: William A. Hoffman conducted research in parasitology at the School of Tropical Medicine, where he worked particularly with *Australorbis glabratus* and other fresh-water snails available to him in conducting field studies. Recently, F. C. Baker (1941) named a planorbid snail in his honor. Paul Bartsch, of the United States National Museum, visited

Puerto Rico and stated (1930: 101) that he was able to examine "the entire eastern mountain complex" as well as "to explore many of the limestone hills of the north range between San Juan and Arecibo, all of which yielded an abundance of interesting and important land mollusks." William J. Clench visited the island briefly in 1937 and collected land shells from the region of Cataño. During June, 1938, P. J. Darlington discovered *Mcleania darlingtoni* in the Maricao National Forest. The most important contributor since the time of Blauner and Gundlach has been H. B. Baker, who spent two months in 1939 carefully collecting in critical regions. He has described several new species and has obtained sufficient living material to make substantial contributions to comparative morphology and phylogeny. He has also contributed considerably to my efforts to gain information about the ecology and distribution of many of the less common species.

## LAND SHELLS

### KEY TO LAND SHELLS

1 *a.* Shell present ..... 2
  *b.* Shell absent ..... 74
2 *a.* With operculum ..... 3
  *b.* Without operculum ..... 22

#### OPERCULATES

3 *a.* Adult usually more than 8 mm. in height; height greater than diameter ..... 4
  *b.* Adult usually less than 8 mm. in height; height about equal to or less than diameter ..... 13
4 *a.* Usually large (20 mm. in length or more); surface relatively smooth, a more or less uniform grayish white or horn color ..... Genus *Megalomastoma* ..... 5
  *b.* Usually smaller (less than 20 mm. in length); surface with prominent sculpture and often with color bands or blotches ..... 6
5 *a.* Large, common form, white or gray ..... *Megalomastoma croceum* (Pl. II, Fig. 1)
  *b.* Small, stunted, very local, with a brown or horn color. *Megalomastoma verruculosum* (Pl. II, Fig. 2)
6 *a.* Operculum with a spiral, raised ridge ..... Genus *Licina* ..... 7
  *b.* Operculum without a spiral, raised ridge ..... Genus *Chondropoma* ..... 9
7 *a.* Lip with prominent reflection ..... 8
  *b.* Lip without prominent reflection ..... *Licina graminosa* (Pl. II, Fig. 5)
8 *a.* Spiral sculpture on shell prominent ..... *Licina aguadillensis* (Pl. II, Fig. 4)
  *b.* Spiral sculpture on shell faint ..... *Licina decussata* (Pl. II, Fig. 3)
9 *a.* Apertural part of last whorl disjunct ..... 10
  *b.* Apertural part of last whorl only very slightly disjunct, if at all ..... 11
10 *a.* Disjunct condition prominent; last whorl descending obliquely; vertical sculpture prominent ..... *Chondropoma conseptum* (Pl. II, Fig. 8)
  *b.* Disjunct condition less prominent; last whorl not descending obliquely; spiral sculpture very prominent ..... *Chondropoma swifti* (Pl. II, Fig. 10)
11 *a.* Sculpture coarse and prominent with a wide flare of the lip. *Chondropoma yunquei* (Pl. II, Fig. 9)
  *b.* Sculpture fine; prominent color bands or blotches usually present ..... 12

12 *a.* Narrow and attenuate; color patterns variable ..... *Chondropoma riisei* (Pl. II, Fig. 6)
*b.* More ponderous; rays fine, spirally arranged and broken: *Chondropoma blauneri* (Pl. II, Fig. 7)

13 *a.* Flat or coiled in one plane (planorboid). *Ceratodiscus portoricanus* (Pl. I, Fig. 8)
*b.* Triangular in outline ..... 14

14 *a.* Sculpture consisting of spiral or oblique ridges ..... 15
*b.* Sculpture not prominent; either fine growth lines or surface polished ..... 18

15 *a.* Whorls not carinate; sutures not impressed ..... 16
*b.* Whorls carinate; sutures impressed; sculpture microscopic ..... 21

16 *a.* Operculum covering aperture in lidlike fashion; shell minute (diameter, 2 mm.); greenish ..... *Fadyenia portoricensis* (Pl. I, Fig. 7)
*b.* Operculum withdrawn into aperture when retracted; 3–6 mm. in diameter; usually reddish ..... 17

17 *a.* 5–6 mm. in diameter; sculpture spiral or circumlinear. *Lucidella umbonata* (Pl. I, Fig. 6)
*b.* 3–4 mm. in diameter; sculpture oblique ..... *Lucidella vinosa* (Pl. I, Fig. 5)

18 *a.* Relatively large (diameter, 8–12 mm.); subglobose or bell-shaped in outline ..... 19
*b.* One-half as large (diameter, 4–5 mm.); conical in outline, with whorls somewhat flattened; yellow or red ..... *Alcadia alta* (Pl. I, Fig. 3)

19 *a.* Growth lines fine, but visible without a lens; surface not polished ..... 20
*b.* Growth lines not visible without a lens; surface polished; base of columella flattened ..... *Alcadia hjalmarsoni* (Pl. I, Fig. 2)

20 *a.* Nepionic whorls not raised; umbilical notch not pitted. *Alcadia striata* (Pl. I, Fig. 1)
*b.* Nepionic whorls raised; umbilical notch pitted. *Helicina phasianella* (Pl. I, Fig. 4)

21 *a.* Medium size (diameter, 4–5 mm.); last whorl dropping slightly below the preceding ..... *Stoastomops boriqueni* (Pl. I, Fig. 10)
*b.* Small (diameter, 2.5 mm.); last whorl dropping considerably below the preceding. *Stoastomops puertoricana* (Pl. I, Fig. 9)

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22 *a.* Left coiled or sinistral ..... 23
*b.* Right coiled or dextral ..... 24

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*b.* Attenuate, elongate (length, 15–20 mm.), tightly coiled, brown, polished, lip simple. *Obeliscus dominicensis hasta* (Pl. V, Fig. 1)

24 *a.* Flattened (about twice as wide as high) ..... 25
*b.* Elongate or attenuate ..... 45
*c.* Capsule-shaped; mostly small (one exception), usually brown, with or without teeth in aperture ..... 66
*d.* Ovate, thin and fragile; aperture two-thirds or more the size of the shell (Succineidae) ..... 71

25 *a.* Large, flat (width, 20 mm. or more); about twice as wide as high; usually with a more or less prominent flare at the outer edge of lip ..... 26
*b.* Flat, medium size (diameter, 8–20 mm.); about twice as wide as high ..... 30
*c.* Small, flat (diameter, 7 mm. or less) ..... 36

26 *a.* With sculpture; moderately large (smallest diameter, abut 25 mm. or less) ..... 27
*b.* Without prominent sculpture; relatively large (smallest diameter, about 30 mm. or more) ..... 28
27 *a.* Sculpture usually granular and scalelike ..... *Polydontes lima* (Pl. VI, Fig. 8)
*b.* Sculpture striate by virtue of the prominently raised growth lines or varices. *Zachrysia auricoma* (Pl. VI, Fig. 11)
28 *a.* More or less uniformly brown ..... 29
*b.* Banded; a prominent black band arranged spirally along the top and center of whorl ..... *Pleurodonte marginella* (Pl. VI, Fig. 6)
*c.* Opaque, white; top of shell almost flattened, producing an acute angle at outer edge of last whorl ..... *Pleurodonte acutangula* (Pl. VI, Fig. 10)
29 *a.* Large, flat, with a low spire ..... *Pleurodonte carocolla* (Pl. VI, Fig. 7)
*b.* Medium size, high spire (height almost as great as width). *Polydontes luquillensis* (Pl. VI, Fig. 9)
30 *a.* Widely umbilicate; outer edge of lip not flared in adult; shell smooth and somewhat polished in appearance ..... Genus *Austroselenites* ..... 31
*b.* Narrowly umbilicate; outer edge of lip not flared in adult ..... 32
*c.* Umbilical region imperforate (sealed); outer edge of lip flared in adult ..... 34
31 *a.* Umbilicus larger, whorls less bulky, larger sutural spiral; not common. *Austroselenites alticola* (Pl. V, Fig. 10)
*b.* Umbilicus smaller, whorls more bulky, smaller sutural spiral; common form. *Austroselenites concolor* (Pl. V, Fig. 9)
32 *a.* Spire low, giving shell almost a planorboid appearance; sutures deeply impressed. *Aquebana velutina* (Pl. VIII, Fig. 1)
*b.* Spire prominent; edge of whorl slightly carinate ..... 33
33 *a.* Growth ridges prominent ..... *Cepolis musicola* (Pl. VI, Fig. 12)
*b.* Surface smooth ..... *Cepolis euclasta*
34 *a.* Spire low, with a prominent carination at edge of outer lip; a characteristic notch occurs back of lip on outer whorl ..... *Cepolis squamosa* (Pl. VI, Fig. 13)
*b.* Spire raised (to an obtuse angle) ..... 35
35 *a.* Carination on outer whorl present but not prominent; surface with fine spiral sculpture; flare of outer lip relatively prominent. *Cepolis dermatina* (Pl. VI, Fig. 13)
*b.* Without carination on outer whorl; surface smooth and without any apparent sculpture ..... *Cepolis boriquenae* (Pl. VI, Fig. 14)
36 *a.* Small, flat (diameter, 7 mm. or less); about twice as wide as high ..... 37
*b.* Small, conical (diameter, 2–3 mm.) ..... 41
*c.* Minute, flattened (diameter, 2 mm. or less) ..... 43
37 *a.* Opaque, white or brown; umbilicus usually wide ..... 38
*b.* Vitreous and transparent ..... 39
38 *a.* Spire flat across top (planorboid); whorls coiled tightly with dense lirations visible across whorl under a lens ..... *Yunquea denselirata* (Pl. VI, Fig. 5)
b. Spire flat; upper and outer side of last whorl slightly carinate; fresh specimens often with mud coating ..... *Lacteoluna selenina* (Pl. VI, Fig. 3)
*c.* Spire somewhat elevated; white and smooth; whorls rapidly expanding. *Hyalosagda subaquila* (Pl. VIII, Fig. 2)
39 *a.* Imperforate; incised lines across whorls visible under a lens. *Retinella insecta* (Pl. III, Fig. 10)
*b.* Umbilicate ..... 40

40 *a.* Microscopically spirally striate; whorls more depressed, umbilicus more open. *Retinella subhyalina*

*b.* Finely striate; spire more elevated and whorls more rounded; umbilicus smaller. *Zonitoides arboreus* (Pl. III, Fig. 12)

41 *a.* Not vitreous, growth lines raised and prominent; sutures deeply impressed. *Thysanophora plagioptycha* (Pl. V, Fig. 12)

*b.* Vitreous, smooth, shiny, brown ..... 42

42 *a.* Without sculpture ..... *Habroconus* cf. *ernsti* (Pl. III, Fig. 8)

*b.* With fine microscopic spiral lines along lower surface of last whorl. *Guppya gundlachi* (Pl. III, Fig. 7)

43 *a.* Surface smooth; spire somewhat elevated; somewhat iridescent or opalescent. *Miradiscops* (Pl. IV, Fig. 4)

*b.* Surface sculptured ..... 44

44 *a.* Very finely striate; altitude, 1 mm. ..... *Hawaiia minuscula* (Pl. III, Fig. 9)

*b.* Surface microscopically spirally striate, with distant longitudinal oblique ribs; altitude, 0.5 mm. ..... *Striatura meridionalis* (Pl. III, Fig. 11)

45 *a.* Surface very shiny, polished, vitreous, not ribbed ..... 46

*b.* Surface not vitreous, opaque, white or colored, often ribbed ..... 59

46 *a.* Long, polished, vitreous, brown, and often with brown vertical color bands ..... 47

*b.* Long, narrow, not brown but pale green, transparent or white ..... 51

47 *a.* Large (length, 20–40 mm.); length of aperture almost half the length; base of columella decidedly twisted ..... 48

*b.* Medium size (length, 16–20 mm.); length of aperture only about one-third the length ..... 49

*c.* Small (length, 15 mm. or less); length of aperture about one-third the length ..... 50

48 *a.* Long and narrow; width in proportion to length in the order of 10 to 30; growth striae not prominent along shoulder of whorl ..... *Laevaricella playa* (Pl. V, Fig. 6)

*b.* Long but more robust; width in proportion to length in the order of 13 to 30; growth striae prominent along shoulder of whorl. *Laevaricella glabra* (Pl. V, Fig. 7)

49 *a.* Tapering gradually from apex to base; color bands present or absent, but if present not broken ..... *Varicella portoricensis* (Pl. V, Fig. 8)

*b.* Uneven taper due to bulging of last whorl; vertical color bands present with "interruption" or a break in the band along center of the whorl. *Laevaricella interrupta* (Pl. V, Fig. 5)

50 *a.* Length, 13–15 mm.; growth lines more closely spaced than in *V. portoricensis.* *Varicella calderoni* (Pl. V, Fig. 2)

*b.* Length, 10–12 mm.; width in proportion to length in the order of 1 to 3; shell more conic than following species, with longer whorls and larger aperture. *Varicella sporadica* (Pl. V, Fig. 3)

*c.* Length, 10–12 mm.; narrow and attenuate; width in proportion to length in the order of 1 to 4 ..... *Varicella terebraeformis* (Pl. V, Fig. 4)

51 *a.* Large or medium size (length, 6 mm. or more) elongate forms ..... 52

*b.* Minute, elongate (length, 5 mm. or less); very small, slender, narrowly lanceolate; smooth, transparent or an opaque white; aperture about one-third the length ..... 58

52 *a.* Narrow, elongate, with flattened tapering whorls; white or green, not brown; apex more pointed; lower part of columella not noticeably truncate but passing continuously into lower part of lip ..... 53

*b.* Narrow, elongate, with numerous rounded and tapering whorls; apex bluntly rounded; lower end of columella with a strong twist; shell white, gray, or green, rarely brown ..... 54

53 *a.* Small (length, 7–10 mm.), slender and glossy; whorls 7 to 9.
*Obeliscus swiftianus* (Pl. IV, Fig. 10)
*b.* Large (length, 12–30 mm.), finely striate, whorls 9 to 10.
*Obeliscus terebraster* (Pl. IV, Fig. 9)
54 *a.* Base of columella decidedly truncate ..... 55
*b.* Base of columella curving evenly into basal margin; not truncate or sinuate ..... 56
55 *a.* Short (length, 5–7 mm.); whorls ribbed, spire obtuse, blunt and rounded.
*Lamellaxis micra* (Pl. IV, Fig. 12)
*b.* Short (length, 5–7 mm.); whorls with characteristic curved striae; spire more pointed ..... *Opeas pumilum* (Pl. IV, Fig. 7)
*c.* Longer (7–9 mm.); whorls more rounded, with well-spaced striae which become heavier below the sutures ..... *Lamellaxis gracilis* (Pl. IV, Fig. 11)
56 *a.* Slender (length, 12–20 mm.); aperture less than one-third the length.
*Subulina octona* (Pl. IV, Fig. 14)
*b.* Short, broad, and conic; aperture about one-third the length ..... 57
57 *a.* Large (length, about 10 mm.); diameter about one-half its length; a lamellar plate on columellar wall in aperture ..... *Lamellaxis unilamellata* (Pl. IV, Fig. 13)
*b.* Small (length, 5 mm.); less robust; without a lamellar plate on axial side of aperture ..... *Lamellaxis monodon opalescens* (Pl. IV, Fig. 8)
58. *a.* Short (length, 2 mm.); columella truncate *Cecilioides consobrina* (Pl. IV, Fig. 6)
*b.* Long (length, 5 mm.); columella continuous with basal lip.
*Cecilioides gundlachi* (Pl. IV, Fig. 5)
59 *a.* Long and wide (width, about half the length); white, opaque without rays; or brown and banded; nuclear whorls with minute dense granulations ..... 60
*b.* Long or short, cylindric, fusiform; whorls usually flattened; last whorl adnate or free; aperture expanded or reflexed; all species in this group almost exclusively on limestone ..... 62
60 *a.* Small (length, 20–25 mm.); usually brown, with or without prominent dark brown bands; nuclear whorls with granulations in a zigzag arrangement.
*Bulimulus exilis* (Pl. VII, Fig. 1)
*b.* Large (length, 25–30 mm.); microscopic granulations on nuclear whorls in a cross-hatch or lattice arrangement ..... 61
61 *a.* Opaque, white with a bluish cast along apical region; aperture white.
*Drymaeus liliaceus* (Pl. VIII, Fig. 4)
*b.* Often colored; banded or streaked with various colors; aperture usually having a tinge of coloring ..... *Drymaeus virgulatus* (Pl. VIII, Fig. 3)
62 *a.* Narrow and elongate, ribbed, last whorl free and expanded obliquely downward ... 63
*b.* Broad-elongate, forming a long or short cone ..... 65
63 *a.* Length, 9–13 mm.; surface somewhat glossy with minute riblets; suture simple.
*Brachypodella portoricensis* (Pl. VIII, Fig. 7)
*b.* Small (length, 7–10 mm.); ribs rather stout ..... 64
64 *a.* Ribs low, but heavier at suture ..... *Brachypodella riisei* (Pl. VIII, Fig. 6)
*b.* Ribs stout, heavy across whorls; shell usually whiter than in the preceding species.
*Brachypodella pallida* (Pl. VIII, Fig. 8)
65 *a.* Broad and conical in outline; apical whorls smooth (length, 15 mm.; width, about 5 mm.); gray with longitudinal brown streaks; whorls slightly convex with vertical riblets ..... *Macroceramus microdon* (Pl. VII, Fig. 2)
*b.* Broad and conic in outline; apical whorls ribbed (length, 7 mm.; width, about 3 mm.); whorls covered with widely spaced growth threads.
*Microceramus guanicanus* (Pl. VII, Fig. 4)

66 *a.* Teeth in aperture ..... 67
*b.* Without teeth in aperture ..... 70
67 *a.* Length, about 15 to 20 mm. ..... *Cerion crassilabris* (Pl. VII, Fig. 5)
*b.* Length, about 6 mm.; suture of whorl lined with crenulations. *Gulella bicolor* (Pl. V, Fig. 11)
*c.* Length, less than 6 mm. ..... 68
68 *a.* Surface smooth; minute (length, 1.5–2.0 mm.) ..... 69
*b.* Surface minutely and densely pitted (length, 1.5 mm.) *Bothriopupa tenuidens* (Pl. III, Fig. 3)
69 *a.* Somewhat more robust (length, 2 mm.); brown. *Gastrocopta servilis* (Pl. III, Fig. 5)
*b.* Shell smaller (length, 1.5 mm.); light gray ... *Gastrocopta pellucida* (Pl. III, Fig. 6)
70 *a.* Surface of shell smooth; shell relatively large (length, 4–5 mm.). *Pupoides nitidulus* (Pl. III, Fig. 4)
*b.* Surface with minute spiral striae; minute (length, 1.5–2.0 mm.). *Pupisoma dioscoricola* (Pl. III, Fig. 2)
*c.* Surface pitted-granulose; minute (length, 1.35 mm.). *Pupisoma minus* (Pl. III, Fig. 1)

SUCCINEIDAE

71 *a.* Large forms (length, about 20 mm.); width about equal to length; surface with prominent growth striae ..... *Platysuccinea portoricensis* (Pl. VI, Fig. 2)
*b.* Medium size (length, about 10 mm.); width about one-half length; growth striae barely visible but not prominent ..... 72
72 *a.* Robust, white, opaque ..... *Succinea riisei* (Pl. IV, Fig. 3)
*b.* Thin, brownish, transparent ..... 73
73 *a.* Spire long; last whorl more swollen ..... *Succinea approximans* (Pl. IV, Fig. 1)
*b.* Spire short; less swollen ..... *Succinea hyalina* (Pl. IV, Fig. 2)

SLUGS

74 Large flat slugs; foot tripartite ..... *Vaginulus occidentalis*

## FAMILY HELICINIDAE

### *Alcadia striata* (Lamarck)

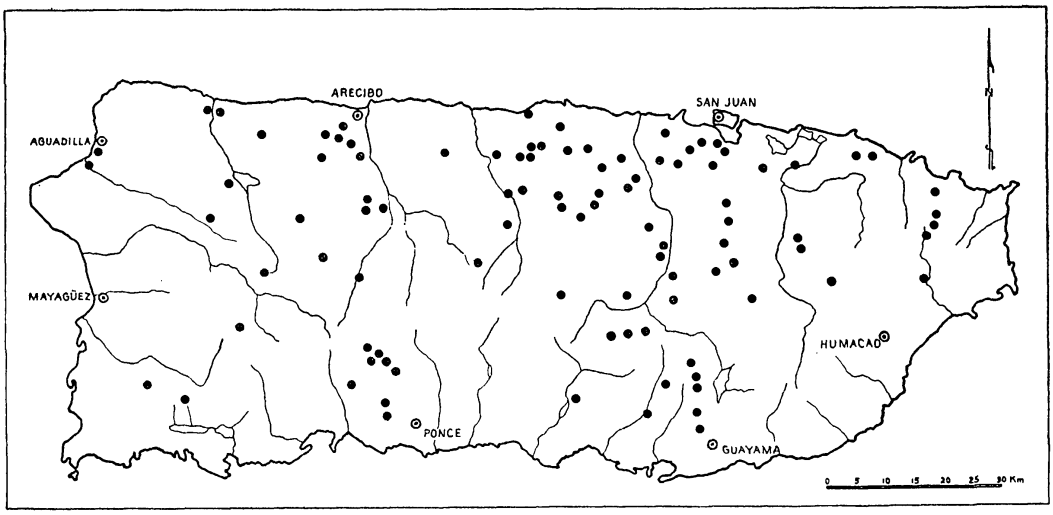
(Pl. I, Figs. 1*a*, *b*)

***Helicina striata*** **Lamarck,** ***Histoire des animaux sans vertèbres . . .*** **, VI (1822): 103.**
*Alcadia* (*?*) (*Striatemoda*) *striata* Lamarck, H. B. Baker, *Nautilus*, 54 (1940): 71.

*Subulina octona* and *A. striata* are two of the most common mollusks in Puerto Rico. Most authors dealing with *striata* have suggested that *A. subfusca,* named by Menke in 1828, is only an immature form of *A. striata.* This idea has been expressed by Shuttleworth (1854: 93), E. von Martens (1877: 343), and H. Crosse (1892: 48), but Dall and Simpson (1901: 447) persisted in recognizing *A. subfusca* as a distinct species. Anton Wagner (1911: 93) also considered *subfusca* to be the immature form of *A. striata.* The name *A. striata subfusca* is applied to the specimens of smaller size having a thin and simple lip. Most of the specimens in Puerto Rico are of this very common form. The larger shells with the thickened peristome (occurring with the smaller specimens having an undeveloped lip)

are very rare. It appears that in this species the animals may be sexually mature before the shell shows the thickened peristome usually associated with sexual maturity among land snails. H. B. Baker (1926: 45) stated: "However, as all of my specimens approach sexual maturity, it seems probable that this apparently paedogenetic form has at least racial significance." Life-history studies bearing on this common *Alcadia* in Puerto Rico should be undertaken. It may be that the rare larger specimens (true *A. striata*) are the few that survive a second or third year, at least beyond the season when the bulk of the population reproduces and dies.

The ability of *A. striata* to adapt itself to a wide range of conditions probably accounts for its occurrence (Map 2) throughout the island. During




MAP 2. Distribution of *Alcadia striata*.

dry periods specimens were taken usually under leaves and stones, and in wet periods from low trees and shrubs. Often specimens were along roadsides and in places that were considerably changed by construction projects of various kinds.

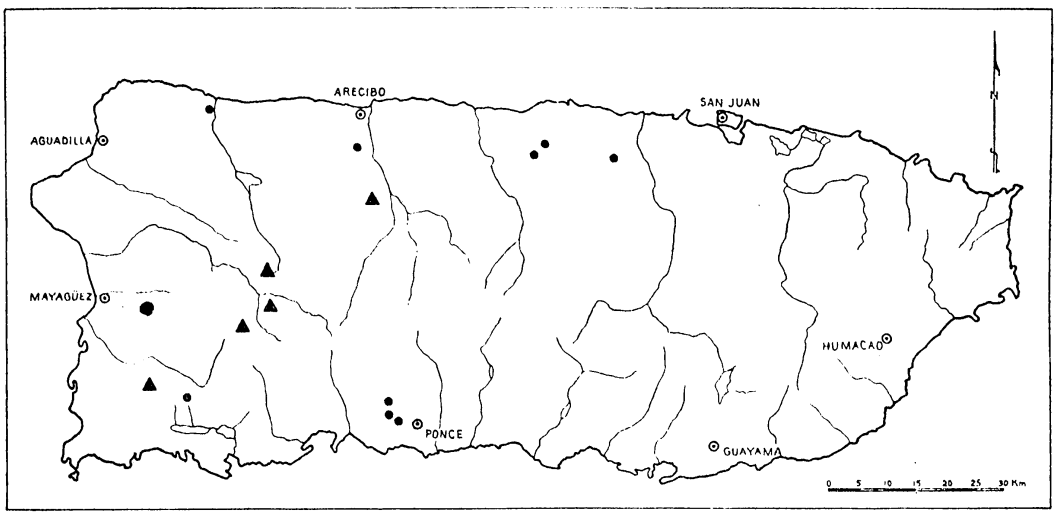
## *Alcadia hjalmarsoni* (Pfeiffer)

(Pl. I, Fig. 2)

*Helicina Hjalmarsoni* Pfeiffer, *Malak. Blätt.*, 3 (1856): 50.
*Alcadia* (*Hjalmarsona*) *hjalmarsoni* (Pfeiffer), H. B. Baker, *Nautilus*, 54 (1940): 70.

This striking shell has a yellowish brown, polished epidermis and a very characteristic notch at the base of the columella.

Originally, Hjalmarson gave the locality for the type material as between Arecibo and Ponce. In the light of more recent collecting it appears that such a line drawn across the island would mark the eastern limit in the range of this species. *A. hjalmarsoni* is found mostly in the high, wooded mountainous part of the western third of the island (Map 3). Ad-




MAP 3. Distribution of *Lucidella umbonata* (circles) and *Alcadia hjalmarsoni* (triangles).

ditional records, which also show its range to be "west of Utuado," are given by Baker: "Maricao, Montoso, and west of Santa Ana Peak." A record of two specimens from a limestone knoll about 2 kilometers south of San German indicates that, occasionally, *A. hjalmarsoni* may occur at lower altitudes in less wooded regions, although most specimens of this rather local species were in the more densely forested parts of the western mountain mass.

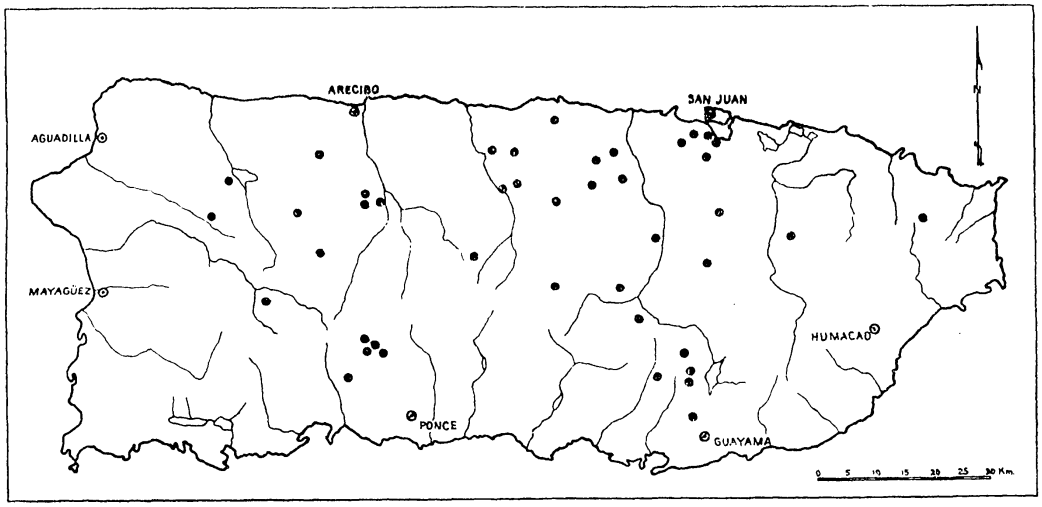
## *Alcadia alta* (Sowerby)

(Pl. I, Fig. 3)

*Helicina alta* Sowerby, *Thesaurus Conchyliorum*, III (1866): 288, Pl. 272, Figs. 251–52.
*Helicina trochulina* Crosse, *Journ. de conchyl.*, 40 (1892): 49, *non* D'Orbigny, *Mollusques . . . Cuba*, I (1841): 249, Pl. 20, Figs. 10–12.
*Alcadia* (*Lcialcadia*) *trochulina* D'Orbigny, Wagner, *Systematisches Conchylien Cabinet*, I, Abt. 18 (1911): 71.

This small, conical, yellow or red species in Puerto Rico is given the name of *Helicina trochulina* D'Orbigny by Shuttleworth, E. von Martens, and Crosse. Baker in notes stated that *A. alta* "has more convex outlines than the Cuban *Eutrochatella trochulina* (Orb.), which has been confused with it. It is polished at all stages of growth." Anton Wagner (1911: 71) in his contribution to the *Conchylien-Cabinet* placed *A. alta* (Sowerby) in the synonymy under *Alcadia trochulina* D'Orbigny. Since little comparative material is available, I cannot express an opinion regarding these distinctions. The constructive suggestion for a change from the name generally used is being accepted.

*A. alta* (Map 4) is relatively common throughout the island. Sizeable series were taken both in the limestone outcrops of haystack knolls in the




MAP 4. Distribution of *Alcadia alta.*

northern coastal plain, as well as in parts of the higher mountain mass south of Cayey and Adjuntas. Additional records are given by Shuttleworth (1854: 93–94), who reported that Blauner collected the form at Humacao. Rio Blanco, and Luquillo; H. B. Baker found it at Palo Seco along the north coast, at Montoso, and "west of Santa Ana peak" in the southwest.

## *Helicina phasianella* "Sowerby" Pfeiffer

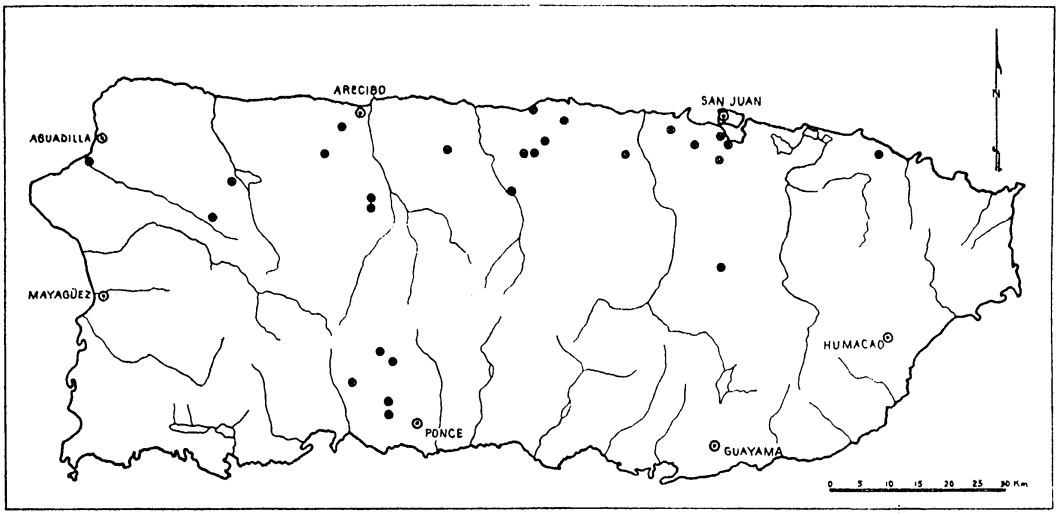
(Pl. I, Fig. 4)

*Helicina phasianella* Sowerby, *in* Pfeiffer, *Malak. Blätt.*, 3 (1856): 50.

*Helicina phasianella* Sowerby Pfeiffer, von Martens, *Jahrb. d. deutschen malak. Gesellsch.*, 4 (1877): 343–44.

*Helicina phasianella* Sowerby, Dall, and Simpson, "The Mollusca of Porto Rico," 1901, p. 447.

The peculiarly raised nepionic whorls, the irregular sculptural lines of the epidermis, the definitely pitted notch in the umbilical callus, and the bright, variable coloration, readily distinguish this species. Shuttleworth (1854: 94) reported that *H. fasciata* Lamarck was collected by Blauner from the region of San Juan and Humacao. Later, E. von Martens (1877: 343–44) reported only *H. phasianella* and suggested that Shuttleworth confused *fasciata* with *phasianella.* H. Crosse (1892: 48–49) listed, of necessity, both *H. fasciata* and *phasianella,* and under the latter he suggested that they should perhaps be united; in the absence of evidence he left the matter open. In notes given to me by H. B. Baker there is the following statement: "*Helicina* (s.s.) *phasianella* 'Sowerby' Pfr.: . . . All stages are more elevated than *H. fasciata* Lamarck, originally described inadequately and often quoted as from Puerto Rico, but fixed by Gray on a species from Guadeloupe." With but a limited amount of comparative material available, it seems advisable to accept Baker's statement, which would definitely establish *H. phasianella* as the species common in Puerto Rico.




MAP 5. Distribution of *Helicina phasianella.*

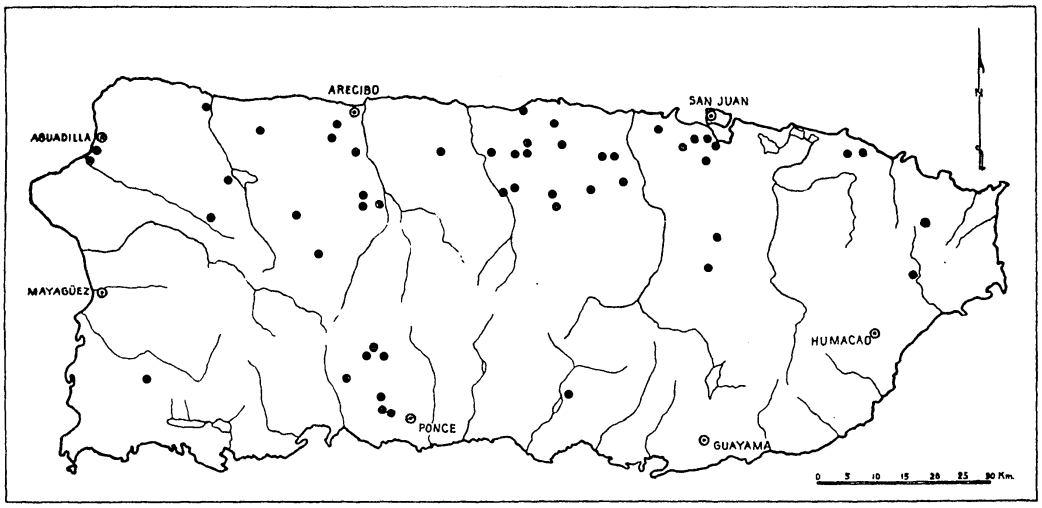
This species (Map 5) occupies a wide belt across the northern half of the island from Humacao (Blauner's record) westward to Aguadilla. Along the south coast it is taken mainly in the region west of Ponce. Baker has given two important records in addition to those shown on the map: west of Santa Ana peak (3000 feet elevation) and south of the town of Cabo Rojo. It has not been collected in the central mountain mass. In its range *H. phasianella* is decidedly a rare species and seldom are there more than a few specimens at a locality. The best series taken was found among the limestone, haystack knolls of the north coastal plain and along ledges of a prominent limestone outcrop on the road from Arecibo to Lares.

## *Lucidella vinosa* (Shuttleworth)

(Pl. I, Figs. 5*a*, *b*)

*Helicina vinosa* Shuttleworth, "Diagnosen . . . ," 1854, p. 92.
*Helicina vinosa* Shuttleworth, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 447.

This very characteristic little species is among the most common of the small Helicidae in the island. As the fifty-eight localities in Map 6 indicate, specimens are common along the north coast, where the form occurs in a broad band across the coastal plain southward well into the foothills. It is less common along the south coast, but there are sufficient records to establish it definitely there. *L. vinosa* does not occur in the dense rain forest. Some of Shuttleworth's original specimens were taken by Blauner in the vicinity of Humacao, so that it is probable that this species goes completely around the island. The most thriving colonies were in shaded areas wherever dense moist leafmold covered limestone outcrops.




MAP 6. Distribution of *Lucidella vinosa.*

## *Lucidella umbonata* (Shuttleworth)

(Pl. I, Fig. 6)

*Helicina umbonata* Shuttleworth, "Diagnosen . . . ," 1854, p. 93.
*Helicina umbonata* Shuttleworth, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 447.

In contrast to *L. vinosa, L. umbonata* is a relatively local species in this island. It inhabits dry limestone outcrops of a narrow belt in the coastal plain of the north and south (Map 3). Along the north coast, it seems to range somewhat farther east, and there it was collected among the haystack knolls in the vicinity of Vega Alta and Manati. H. B. Baker has kindly given additional records which add the region of Guanica and the region just south of the town of Cabo Rojo to the stations already mentioned. Stout, white epidermal hairs have been seen on an immature specimen. This observation has also been indicated in correspondence by Baker, who stated that though these hairs are more common among young specimens, adults may occasionally retain them.

## *Fadyenia portoricensis* (Pfeiffer)

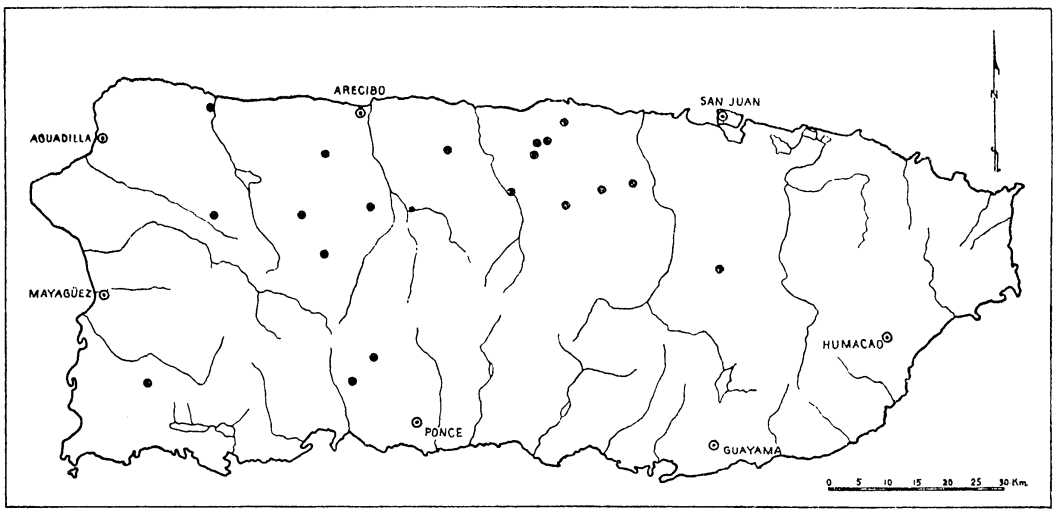
(Pl. I, Fig. 7)

*Stoastoma portoricense* Pfeiffer, *Malak. Blätt.*, 3 (1856): 51.
*Stoastoma portoricense* Pfeiffer, Crosse, *Journ. de conchyl.*, 40 (1892): 46.

The type specimens were collected by Hjalmarson from a plantation near Manati. The nineteen locality records (Map 7) obtained in addition to those given by Baker show that this species is confined largely to the western part of the island. It occupies a broad belt across the coastal plain and foothills of the north part of the island, extending from the region of the caves at Aguas Buenas westward. In the southwest it is less common and

appears to be restricted to foothills and plains west of Ponce. Baker in notes submitted added "west of Santa Ana Peak" to the southwestern stations given. He also stated that it did not seem to be a marked calciphile in Puerto Rico and that he found it at an elevation of 3000 feet.

H. Crosse (1892: 46) claimed that the finding of the genus *Stoastoma* (meaning *Fadyenia*) in Puerto Rico by Justus Hjalmarson was an important discovery from a zoogeographical point of view, since the occurrence of the animal in both Santo Domingo and Puerto Rico "unites each of the two faunas with that of Jamaica, where is found the center of its development




MAP. 7. Distribution of *Fadyenia portoricensis.*

and, so to speak, the metropolis of this small and curious genus." H. B. Baker (1934: 13–14), after studying the radulae, limited *Stoastoma* (Vianinae) to the typical species and included the other seven under *Fadyenia,* which is closely related to *Lucidella* and *Ceratodiscus.* The statement by Crosse regarding the possible zoogeographical significance of this group is not altered by these taxonomic changes.

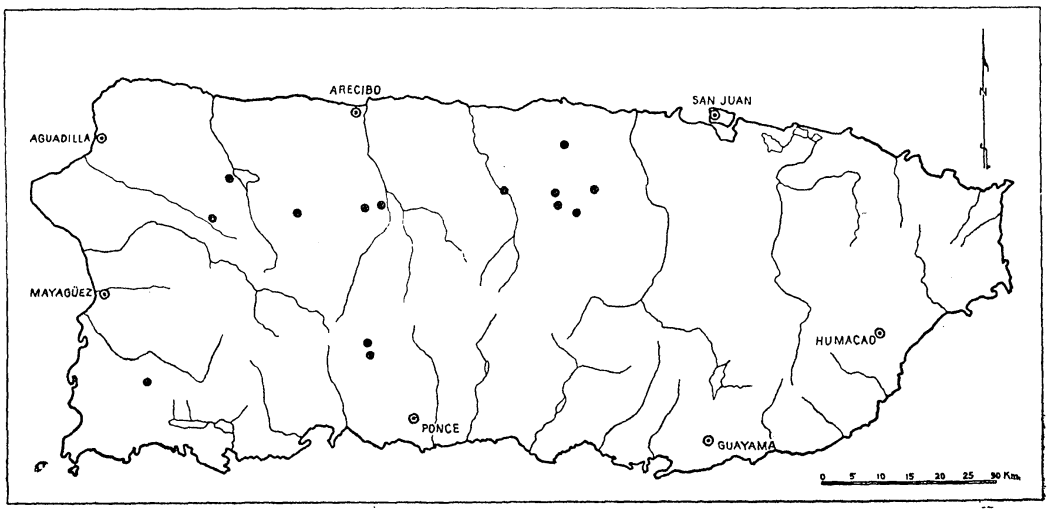
## *Ceratodiscus portoricanus* Pilsbry and Vanatta

(Pl. I, Figs. 8*a, b, c*)

*Ceratodiscus portoricanus* Pilsbry and Vanatta, *Proc. Acad. Nat. Sci. Phila.,* LXXIX (1927): 21–22.

Fresh specimens of this species (Pl. I, Fig. 8*c*) usually have soil attached to the shell, giving the whorls a bicarinate appearance. The species was most common (Map 8) in the western half of the island. Pilsbry and Vanatta (1927: 21–22) originally described it from a specimen taken from "the summit of Montoso, 2624 ft., Division of Mayaguez." It appeared to be in the foothills and higher parts of the western half of the island, although

H. B. Baker found it at sea level near the mouth of Rio Guajataca. A record established at Corozal indicates that it may range considerably farther eastward along the north coast than it does in the south. Baker reported that its habits and habitats seemed very similar to those of *Fadyenia,* to which it is fairly closely related.




MAP 8. Distribution of *Ceratodiscus portoricanus.*

## *Stoastomops puertoricana* H. B. Baker

(Pl. I, Fig. 9)

*Stoastomops (s.s.) puertoricana* H. B. Baker, *Notulae Nat.*, 88 (1941): 1, Fig. 1.

The specimens figured are from the type lot and were kindly given for illustration by Baker. In addition to the original description and a figure of the type he (1941: 1) gave the following information:

On limestone rock-faces, often under edges, near base of cliffs at head of valley behind Cerro Capron (PS2), east of entrance to Guanica Harbor; frequent. Type lot 177655 A.N.S.P. The type is a fairly large example (sex undetermined) of the greenish yellow color-form, which is more common than the reddish one.

## *Stoastomops boriqueni* H. B. Baker

(Pl. I, Fig. 10)

*Stoastomops (Swiftella) boriqueni* H. B. Baker, *Notulae Nat.*, 88 (1941): 1, Figs. 2–3.

In the summer of 1939 this species was discovered by Baker in southwestern Puerto Rico. In addition to an accurate description and figure he (1941: 2) gave the following data:

Common, under, or weakly climbing on limestone rock-faces, 2 miles southeast of Escuela Manuel Corchada, in Los Peñones (WS1), south of Cabo Rojo (town). Type lot 177656 A.N.S.P. The type is a female of the greenish yellow color form; the males average smaller; both sexes also have the reddish form.

This species and the preceding one are closely related to *Stoastoma;* they represent the only Vianine species known from Puerto Rico.

FAMILY CYCLOPHORIDAE

## *Amphicyclotulus portoricensis* O. Böttger

*Cyclotus portoricensis* Böttger, *Jahrb. d. deutschen malak. Gesellsch.*, 14 (1887): 101–2, Pl. 4, Fig. 7.

*Amphicyclotulus* (*Amphicyclotulus*) *portoricensis* (Böttger) Bartsch, *U. S. Nat. Mus. Bull.*, 181 (1942): 59, Pl. 11, Figs. 19–21.

Seven specimens were given to Oskar Böttger by Otto Goldfuss. They were described as "Cyclotus Portoricensis n.sp. (Taf. 4, Fig. 7 a–c)." Along with the description (Böttger, 1887: 101) the locality data are given as follows: "Hab. Rio blanco in der Sierra de Caduros auf Puertorico." Evidently, the only specimens known are those described by Böttger. More recent collectors have not reported it from this island.

## *Megalomastoma croceum* (Gmelin)

(Pl. II, Figs. 1*a*, *b*)

*Helix crocea* Gmelin, *Systema naturae*, 1792, p. 3655; Martini and Chemnitz, *Systematisches Conchylien Cabinet*, 9 (1786): Pl. 135, Fig. 1233.

*Megalomastoma cylindraceum* Sowerby, *Conchologia Iconica*, XX (1878): Pl. X, Fig. 91.

*Megalomastoma croceum* Gmelin, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 434.

*Megalomastoma hjalmarsoni* Pfeiffer, *Malak. Blätt.*, XXII (1875): 119.

*Megalomastoma hjalmarsoni* Pfeiffer, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 434.

*Farcimen* (*Neopupina*) *hjalmarsoni* (Pfeiffer), Bartsch, *Bull. U. S. Nat. Mus.*, 181 (1942): 45.

*Megalomastoma croceum curtum* Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 434, Pl. 53, Fig. 2.

*Farcimen* (*Neopupina*) *curtum* (Dall and Simpson), Bartsch, *U. S. Nat. Mus. Bull.*, 181 (1942): 44.

*Farcimen* (*Neopupina*) *croceum* (Gmelin) Bartsch, *U. S. Nat. Mus. Bull.*, 181 (1942): 45.

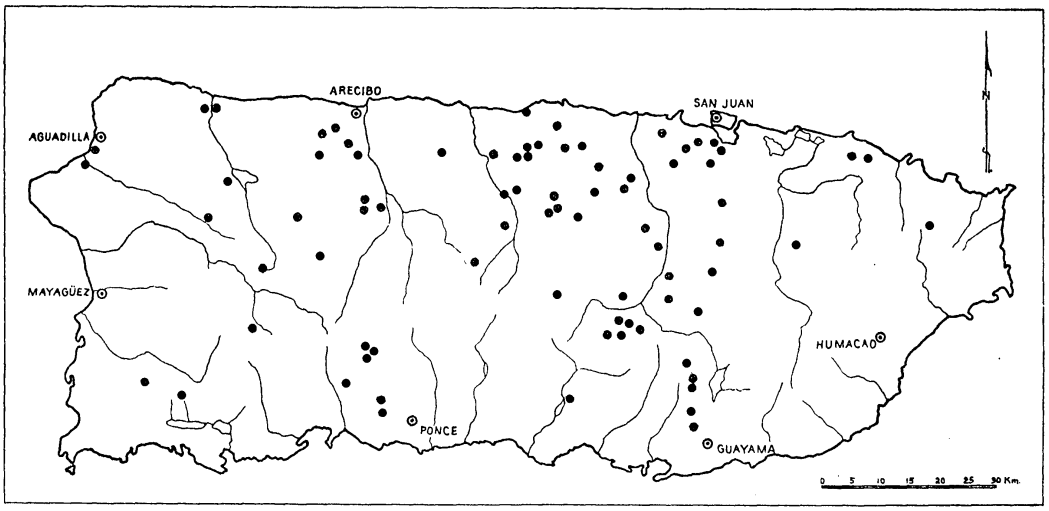
*Megalomastoma croceum* (Gmelin) H. B. Baker, *Nautilus*, 56 (1943): 106–7.

*Megalomastoma croceum* (Gmelin) Bartsch, *Nautilus*, 57 (1943): 30.

Among the larger operculate land snails, this animal is one of the most common and widely distributed (Map 9). It ranges from the low, dry coastal plain regions through the foothills into the high, wet, densely forested parts of the central mountain mass. Large series are found in the soil of the coffee plantations, where this snail finds what appears to be one of its best habitats. During the dry seasons it burrows deep into the soil, resuming activity among the leaves and decaying vegetation whenever they are sufficiently moist.

There is an interesting variation in the size of specimens from various

parts of the island. This observation was made many years ago by E. von Martens (1877: 341–42), who gave essentially all of the important data. More recent observers have added additional proof. He stated that there was considerable difference in the size of specimens from the northern coastal region of Vega Baja (30–38 mm.) as compared with smaller individuals collected near Mayaguez (17.5–22 mm.) and the unusually stunted forms taken in the mountainous interior near Las Marias (15–20 mm.). He also found that as the specimens became smaller they had fewer whorls, and these diminutive specimens in an apparent flared (thickened lip) adult stage retained a more highly developed periostracal sculpture. The stunted forms were described as *M. hjalmarsoni,* a new species, by L. Pfeiffer, but von Martens stated that he doubted the validity of this species.




MAP 9. Distribution of *Megalomastoma croceum.*

The specimens recently gathered at various localities in Puerto Rico have been grouped into four series based on elevation. The altitudes chosen are arbitrary and because of the nature of the variation one would get somewhat the same results regardless of whether fewer or larger intervals in altitude were selected. The stunting of individuals at higher elevations is clearly shown in Table I. One could use a simple length measurement, or, as has been done in the table, an index figure for obesity, which is the length of a specimen divided by its greatest width. This procedure has the advantage of incorporating two dimensions. One should bear in mind, however, that the results show in an inverse way, that is, the larger specimens have a lower index figure and the stunted specimens have a higher one (Table I). It is clear from the measurements that there is a direct correlation between the average size of the *M. croceum* specimens taken in Puerto Rico and the elevations at which they were found (Fig. 1). Also, there is a large overlap in each group, so that as one travels from the lowest altitude to the highest

TABLE I

PERCENTAGE DISTRIBUTION FOR COLLECTIONS OF *Megalomastoma croceum* Made in Puerto Rico and allocated roughly according to elevations.

| Obesity in Per Cent | 0–49′ | | 50′–499′ | | 500′–1499′ | | 1500′– | | Totals | |
|---|---|---|---|---|---|---|---|---|---|---|
| 26 | 5 | 2.0 | ..... | ..... | ..... | ..... | ..... | ..... | 5 | 0.5 |
| 27 | 1 | 0.4 | ..... | ..... | ..... | ..... | ..... | ..... | 1 | 0.09 |
| 28 | 5 | 2.0 | 1 | 0.3 | ..... | ..... | ..... | ..... | 6 | 0.6 |
| 29 | 12 | 4.9 | 2 | 0.5 | 1 | 0.6 | ..... | ..... | 15 | 1.5 |
| 30 | 20 | 8.2 | 9 | 2.3 | 0 | 0.0 | ..... | ..... | 29 | 2.8 |
| 31 | 41 | 16.7 | 16 | 4.0 | 5 | 3.0 | ..... | ..... | 62 | 6.0 |
| 32 | 62 | 25.3 | 30 | 7.7 | 6 | 3.6 | 1 | 0.4 | 99 | 9.6 |
| 33 | 37 | 15.1 | 62 | 15.9 | 22 | 13.1 | 6 | 2.6 | 127 | 12.3 |
| 34 | 33 | 13.5 | 51 | 13.0 | 18 | 10.7 | 6 | 2.6 | 108 | 10.5 |
| 35 | 16 | 6.5 | 74 | 18.9 | 28 | 16.7 | 15 | 6.6 | 133 | 12.9 |
| 36 | 8 | 3.3 | 63 | 16.1 | 31 | 18.5 | 29 | 12.8 | 131 | 12.7 |
| 37 | 4 | 1.6 | 44 | 11.3 | 29 | 17.3 | 39 | 17.1 | 116 | 11.2 |
| 38 | 1 | 0.4 | 22 | 5.6 | 13 | 7.7 | 35 | 15.4 | 71 | 6.9 |
| 39 | ..... | ..... | 6 | 1.5 | 6 | 3.6 | 28 | 12.3 | 40 | 3.9 |
| 40 | ..... | ..... | 6 | 1.5 | 7 | 4.1 | 31 | 13.7 | 44 | 4.3 |
| 41 | ..... | ..... | 3 | 0.8 | 0 | 0.0 | 15 | 6.6 | 18 | 1.7 |
| 42 | ..... | ..... | 2 | 0.5 | 1 | 0.6 | 13 | 5.7 | 16 | 1.6 |
| 43 | ..... | ..... | ..... | ..... | 1 | 0.6 | 5 | 2.2 | 6 | 0.6 |
| 44 | ..... | ..... | ..... | ..... | ..... | ..... | 3 | 1.3 | 3 | 0.3 |
| 45 | ..... | ..... | ..... | ..... | ..... | ..... | 1 | 0.4 | 1 | 0.09 |
| Totals | 245 | 99.9 | 391 | 99.9 | 168 | 100.1 | 227 | 99.7 | 1031 | 100.08 |

many intergrading specimens are taken. For the time being, it is necessary to stress that although there is a correlation in these snails between size and altitude, the factors responsible for the variation are still unknown. One reason for calling attention to this trend in diversity is to give a better evaluation of the names *M. hjalmarsoni* Pfeiffer (1875) and *M. curtum* Dall and Simpson (1901) applied to the extremely stunted forms of this species. Conceivably, there may be an advantage in recognizing the stunted forms

TABLE II

PERCENTAGE DISTRIBUTION BASED ON NUMBER OF WHORLS IN SPECIMENS OF *Megalomastoma croceum* FROM PUERTO RICO ALLOCATED ACCORDING TO ELEVATIONS

| Number Whorls* | 0–49′ | | 50′–499′ | | 500′–1499′ | | 1500′– | | Totals | |
|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 1 | 0.4 | ..... | ..... | ..... | ..... | 1 | 0.4 | 2 | 0.02 |
| 5 | 16 | 6.4 | 28 | 6.6 | 15 | 11.7 | 62 | 27.4 | 121 | 11.8 |
| 6 | 114 | 46.0 | 193 | 45.5 | 76 | 59.4 | 108 | 47.8 | 491 | 49.0 |
| 7 | 101 | 40.7 | 193 | 45.5 | 37 | 28.9 | 52 | 23.0 | 383 | 37.0 |
| 8 | 16 | 6.4 | 10 | 2.4 | ..... | ..... | 3 | 1.3 | 29 | 2.8 |
| Totals | 248 | 99.9 | 424 | 100.0 | 128 | 100.0 | 226 | 99.9 | 1026 | 100.62 |

* Exclusive of nuclear or nepionic whorls, which when present add 1.5 to 2 whorls

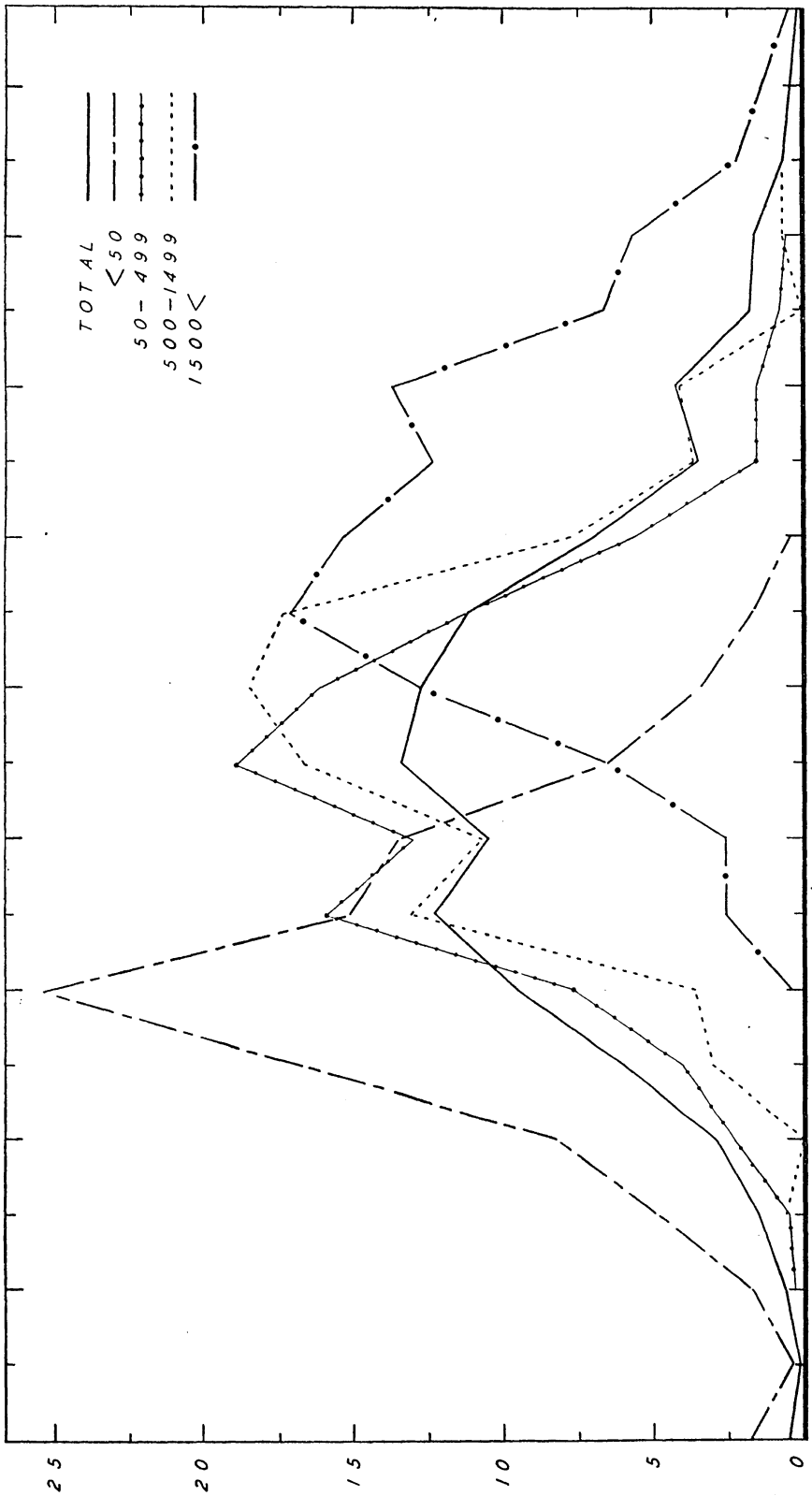



FIG. 1. Based on Table I. A decrease in size of specimens of *Megalomastoma croceum* is correlated with increased land elevation. Points on the abscissa or base of graph represent "obesity," or a percentage figure obtained by dividing the width of a specimen by its length, and consequently the peaks, indicating a dwarfing, move from right to left in the figure.

by applying a special name, and for obvious reasons some evaluation of the taxonomic status of such a name is necessary.

In addition to the stunting or reduction in size, von Martens called attention to a reduction in the number of whorls among specimens taken "in the interior near Las Marias." In order to get a more accurate measure of this reduction a count was made of about a thousand specimens from the various elevations. The results are tabulated in Table II. Although it is true that selected series from the higher elevations have fewer whorls, the difference, as shown in Table II, is variable, with an actual reduction in larger series of less than a complete whorl. Since in many specimens the nepionic or nuclear whorls are broken, the early whorls are excluded from the whorl counts. If they are included, the average number of whorls for the bulk of the population is eight rather than six.

Recently, H. B. Baker (1943: 106–7) published his observations regarding *Megalomastoma* in Puerto Rico. His opinions agree essentially with those given here. Neither Baker's conclusions nor mine substantiate the claims of Bartsch (Torre, Bartsch, and Morrison, 1942; or Bartsch, 1943), who divided the graded variants of *Megalomastoma croceum* of this island into three species (*M. croceum, hjalmarsoni,* and *curtum*).

## *Megalomastoma verruculosum* Shuttleworth

(Pl. II, Fig. 2)

*Cyclostoma* (*Megalomastoma*) *verruculosum* Shuttleworth, "Diagnosen . . . ," 1854, p. 90.

*Megalomastoma verruculosum* Shuttleworth, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 434.

*Megalomastoma* (*Megalomastomoides*) *verruculosum* (Shuttleworth) Bartsch, *U. S. Nat. Mus. Bull.,* 181 (1942): 51.

This species is apparently local. According to the records available, it occurs only at higher elevations in the Luquillo Range of the eastern part of Puerto Rico. It was originally described by Shuttleworth (1854: 90) from Sierra de Luquillo, where Blauner found it on trunks and decaying leaves of banana trees. E. von Martens (1891: 131) reported that Sintenis collected it from the same range at "Ilymenie, Yunque." H. B. Baker, as recorded in his notes, found it at El Yunque along Rio Minas and Big Tree trails below the restaurant where it occurred "in fresh dirt, around rock bases on steep slopes, around 2500 feet. The one living male was smaller than most of the dead shells."

### FAMILY POMATIASIDAE

At present there are two genera in Puerto Rico allocated to the family Pomatiasidae, subfamily Chondropominae. Without recourse to anatomical dissection, these genera can be separated from one another by the characteristic structure of the operculum. On the basis of this criterion the snails

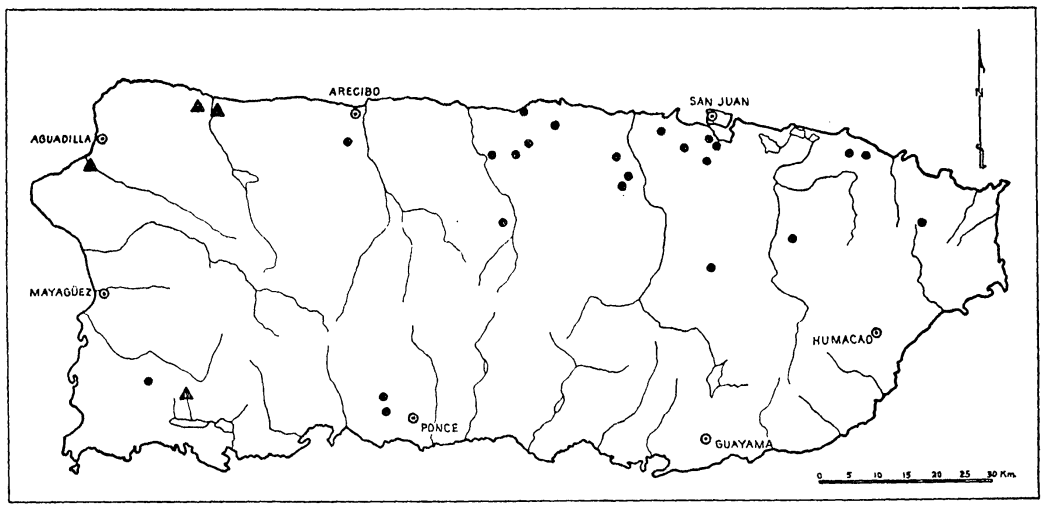
of these groups in Puerto Rico belong to the genus *Licina* if there are prominent, raised spiral ridges on the operculum; if the operculum lacks such spiral ridges the shells belong in the genus *Chondropoma*.

## *Licina decussata* (Lamarck)

(Pl. II, Fig. 3)

*Cyclostoma decussata* Lamarck, *Histoire des animaux sans vertèbres* . . . , VI (1882) : 147.
*Choanopoma decussatum* (Pfeiffer), Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 435.

This is the most common *Licina* in Puerto Rico. It appears to be mainly distributed in the northeastern part of the island (Map 10), although there




MAP 10. Distribution of *Licina decussata* (circles) and *Licina aguadillensis* (triangles).

are isolated colonies along the southwestern coastal plain from Ponce toward Lajas. For some of the variations of the forms that develop in drier regions of the southwest, there are possibly ecological form distinctions. The relative taxonomic value of these forms or varieties is a subject worthy of further investigation. Apparently, Shuttleworth's *C. senticosum* belongs in this category. H. B. Baker in notes on his observations stated: "This seems to be little more than an ecological form, developed in more calcareous habitats; it intergrades completely with the typical form."

## *Licina aguadillensis* (Pfeiffer)

(Pl. II, Fig. 4)

*Cistula aguadillensis* Pfeiffer, *Malak. Blätt.*, 22: (1875) 207.
*Cistula aguadillensis* Pfeiffer, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 435.

As implied in the name, this species is most common in the region of Aguadilla in the northwestern corner of the island (Map 10). In addition

to the records for the northeast there are several for the southwestern region. In his notes, Baker gave varieties of it at several stations there:

Los Peñones; dry brush on limestone capped hills near quarry, about 2 miles southwest of Escuela Manuel Corchado and south of Cabo Rojo. Cerro Capron, Guanica, semi-desert limestone hills east of entrance to Guanica harbor.

## *Licina graminosa* H. B. Baker

(Pl. II, Fig. 5)

*Licina* (*Choanopomops*) *graminosa* H. B. Baker, *Notulae Nat.*, 88 (1941): 2, Fig. 4.

A description and figure of this species was recently published by Baker (1941*c*: 2). In discussing its habitat he stated:

Quite common in soil under edges of bunch-grass on semi-desert limestone hills along south coast near Tallaboa (PS1). . . . . In similar limestone hills near Guanica (PS2), *L. graminosa* (averaging smaller) was found under sunken rocks in the soil of valley flats. . . . . *L. decussata* and the slenderer and more finely ribbed *L. aguadillensis* (Pfr.), both of which were represented by roughly sculptured varieties a few yards away, seemed to prefer the talus slopes and ledges.

## *Chondropoma riisei* (Pfeiffer)

(Fig. 1; Pl. II, Fig. 6)

*Cistula riisei* Pfeiffer *Monographia pneumonopomorum viventium*, 1852, p. 417, 6a.
*Cyclostoma* (*Chondropoma?*) *newtoni* Shuttleworth, "Diagnosen . . . ," 1854, p. 92.
*Chondropoma terebra* Pfeiffer, *Malak. Blätt.*, VIII (1861): 74, Pl. II, Figs. 4–6.
*Chondropoma terebra* Pfeiffer, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 435.
*Chondropoma newtoni* Shuttleworth, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 435.
*Chondropoma riisei* (Pfeiffer) H. B. Baker, *Notulae Nat.*, 88 (1941): 4.
*Chrondropoma riisei newtoni* (Shuttleworth), H. B. Baker, *Notulae Nat.*, 88 (1941): 4 (+ *C. terebra* Pfeiffer (?)).

Two other species are included under this form. A more careful study of this group may produce a better evaluation of the significance of the names *C. newtoni* (Shuttleworth) and *C. terebra* (Pfeiffer), both of which evidently belong in this assemblage. There is a decided sexual dimorphism among these animals, as well as a wide variation in the sculpture and color patterns of the shells (Figs. 2*a* and *b*). In notes submitted by H. B. Baker the following arrangement is suggested:

*C. newtoni*, with *C. terebra* as a synonym, is considered a form of *C. riisei*. Shuttleworth's description of *C. newtoni* appears to be that of a truncated female shell, while Pfeiffer's figure and description of *C. terebra*, which is tentatively considered a synonym, fit entire males.

There is a very characteristic distribution pattern for this species with a range occupying a broad band across the northern half of the island (Map 11). It is most common among the limestone outcrops of small haystack

knolls between Manati and San Juan, but sizeable colonies were collected at somewhat widely scattered locations, such as Gurabo on the east westward to Utuado and San Sebastian.

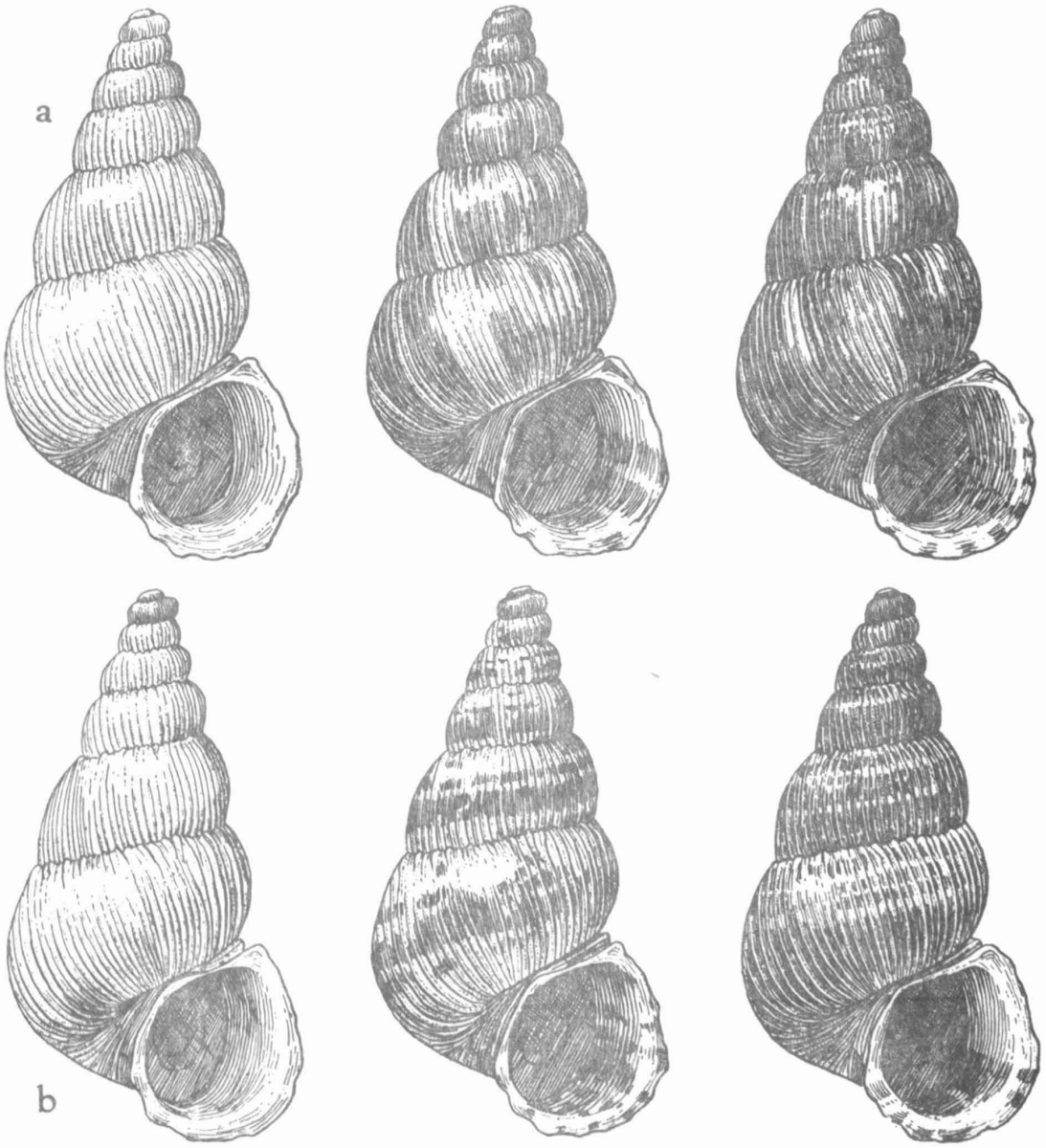



FIG. 2. Color pattern variation in *Chondropoma riisei*, illustrating a trend from colorless through vertical (*a*) and horizontal (*b*) banding.

## *Chondropoma blauneri* (Shuttleworth)

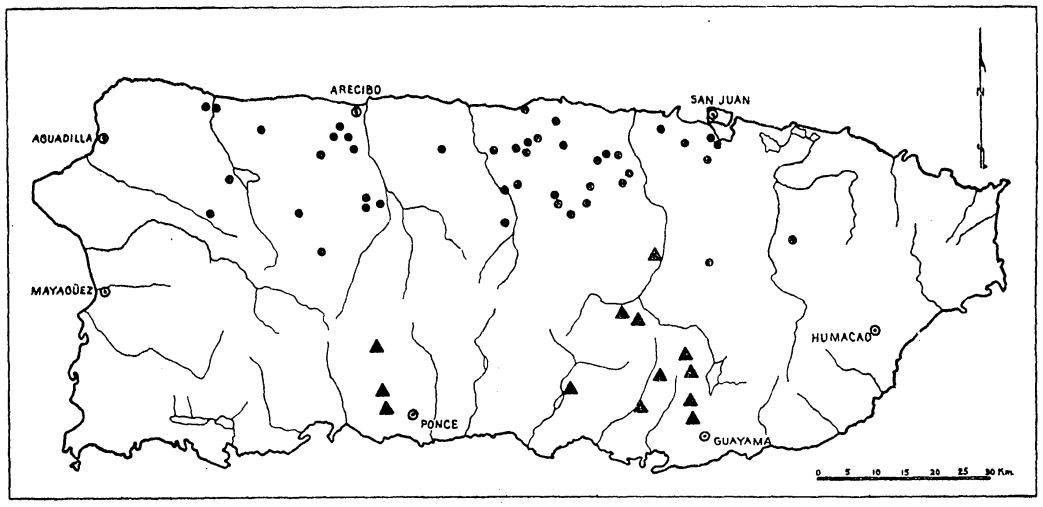
(Pl. II, Fig. 7)

*Cyclostoma* (*Chondropoma*) *blauneri* Shuttleworth, "Diagnosen. . . ," 1854, p. 91.

*Chondropoma blauneri* Shuttleworth, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 435.

*Chondropoma blauneri* (Shuttleworth) H. B. Baker, *Notulae Nat.*, 88 (1941): 4.

The dozen lots of *C. blauneri* represent a closely intergrading series. They (Map 11) have a well-defined range in the south-central part of the island, with records of Shuttleworth and Baker indicating that the range extends eastward to Humacao. Ecologically, these animals appear to be adapted to an environment with fewer exposures of limestone than was observed for *C. riisei.* Apparently, *C. blauneri* has crossed the mountain range in the region of Cayey and has entered the valley of the north flowing Rio de la Plata. This extension of its range is probably not unusual for a species belonging to a group known to be decidedly restricted to lime-




MAP 11. Distribution of *Chondropoma riisei* (circles) and *Chondropoma blauneri* (triangles).

stone exposures. Hill (1899) has pointed out that near Cayey a "black bituminous shaly limestone" is included in the main mountain mass of volcanic rocks, a condition which may partly account for the present distribution pattern of this species.

## *Chondropoma conseptum* (von Martens)

(Pl. II, Fig. 8)

*Cistula consepta* von Martens, *Ann. N. Y. Acad. Sci.*, 2 (1882): 371.
*Cistula consepta* von Martens, *Jahrb. d. deutsch. malak. Gesellsch.*, 10 (1883): 84.

The following translation is from the Latin description given by von Martens (1883: 84):

Shell ovate-conical, umbilicate, closely finely and unevenly lamellate, pale brown, covered with several red figures: whorls 7, the first two smooth, the following increasing regularly, convex, with a deep suture, *fenced off into small enclosures on both sides by the white prolongations of the lamellae;* last ¼ of final whorl separated and descending obliquely; aperture reflected, almost ovate; peristome double, the outer surface subundulate and broadly expanded, spotted with red, the inside distinctly expanded. Operculum pauci-spiral, obliquely radially striate.

Length, 23; diameter, 18½; aperture length including the external peristome 6, width 5½; excluding external peristome 4 and 2½ mm.

This species is not mentioned by Dall and Simpson (1901) nor by Crosse (1892), who gave us the first comprehensive list of the species in Puerto Rico. The fortunate rediscovery of it in the region of Aguas Buenas permits further comparisons with related forms. The operculum structurally indicates that the species belongs in *Chondropoma* and not with the *Licina* group. Distributionally, it is possible that this species may be restricted to the cave region southwest of Aguas Buenas, and it is perhaps because of its restricted range that it has not been collected since the initial discovery of it by R. Swift many years ago.

*C. conseptum* is closely related to *C. tortolense,* and it may be only a form or subspecies of it. A careful study of both species is necessary before their relationships can be established. Both species appear to have a number of characters in common, and the main distinction appears to be in the greater separation of the last whorl in *C. conseptum,* although this may not in itself constitute a significant difference. From the following species, *C. conseptum* seems to differ mainly in sculptural differences, larger size, and more disjunct last whorl.

### *Chondropoma yunquei* H. B. Baker

(Pl. II, Fig. 9)

*Chondropoma* (*Chondropomorus*) *yunquei* H. B. Baker, *Notulae Nat.,* 88 (1941): 3, Fig. 8.

This species was reported by Baker (1941*c:* 3) from El Yunque, where it was found to be "subarboreal, roosting in folded bases of palm-leaflets, between waterfalls above road (kilometer 9.8) between Restaurant El Yunque and Mameyes (ER2); elevation about 2500 ft.; infrequent."

### *Chondropoma swifti* (Shuttleworth)

(Pl. II, Fig. 10)

*Cyclostoma* (*Chondropoma*) *swiftii* Shuttleworth, "Diagnosen. . . ," 1854, p. 91.
*Chondropoma swifti* Shuttleworth, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 435.

Specimens of this species were collected recently by Baker mainly in the region of Ponce, Tallaboa, and Guanica. From his data the species appears limited to the southern coastal limestone west of Ponce.

## FAMILY VERONICELLIDAE

### *Veronicella kraussii* (Férussac)[2]

*?Vaginulus kraussii* Férussac and Deshayes, *Histoire naturelle. . . des mollusques,* II (1823): 96x, Pl. VIII, D, 7, 8.

[2] Where a species is listed without comment it is assumed that there is a possibility of its occurrence in Puerto Rico, but its presence there could not be verified.

*Veronicella (Leidyula) kraussii* (Férussac)? H. B. Baker, *Proc. Acad. Nat. Sci. Phila.*, 77 (1925): 171–74.
*Veronicella kraussii* (Férussac), H. B. Baker, *Nautilus*, 42 (1928): 46.
*Veronicella kraussii* (Férussac), H. B. Baker, *Nautilus*, 48 (1935): 88.

## *Vaginulus occidentalis* (Guilding)

*Onchidium occidentale* Guilding, *Trans. Linn. Soc.*, XIV (1825): 322, Pl. 31, Figs. 8–12.
*Veronicella occidentalis* Guilding, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 372.

## *Vaginulus plebeius* (Fischer)

*Vaginulus plebeius* Fischer, *Journ. de conchyl.*, 16 (1868): 145.
*Vaginulus (Sarasinula) plebeius* (Fischer), H. B. Baker, *Nautilus*, 44 (1901): 134–36.

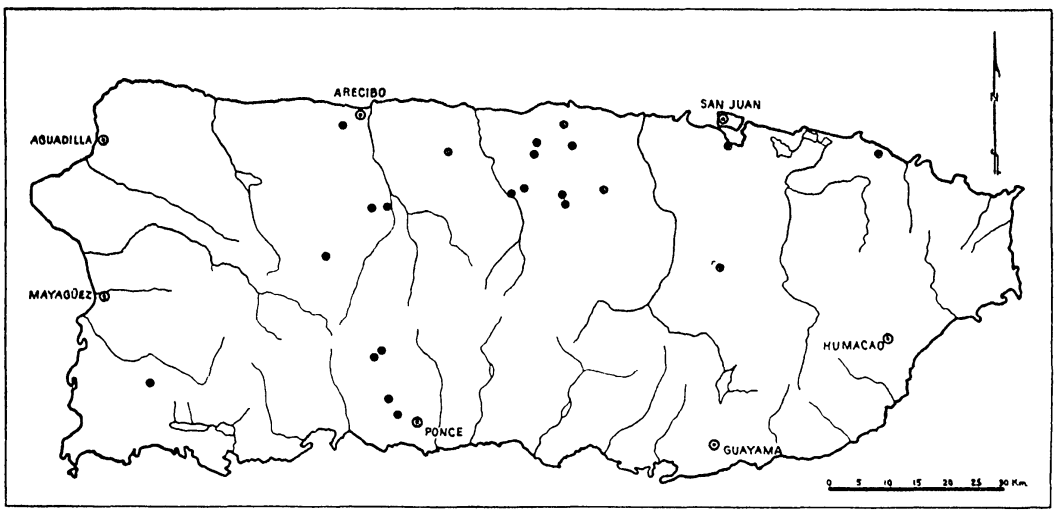
### FAMILY PUPILLIDAE

## *Pupisoma minus* Pilsbry

(Pl. III, Fig. 1)

*Pupisoma minus* Pilsbry, *Manual of Conchology*, 26 (1920): 40–41, Pl. 4, Figs. 9, 11.

Previously, *P. minus* has not been reported from Puerto Rico, where it appears to be well established. This species is reported from several localities in Florida. Pilsbry (1920–21: 41) has a record (two specimens) of it from Chama, Guatemala, and two records (four specimens) from Jamaica. Twenty-two lots were taken in Puerto Rico. Large series were in the vicinity of the prominent limestone outcrops along the northern coastal plain. Apparently, *P. minus* (Map 12) is most common in the small knolls in the vicinity of Manati, Ciales, Corozal, and Vega Baja. Along the southern coastal plain it was found particularly in the southwest on the mountain slope to a considerable height in the region approaching Adjuntas. It was not observed along the main ridge of the Cordillera Central.



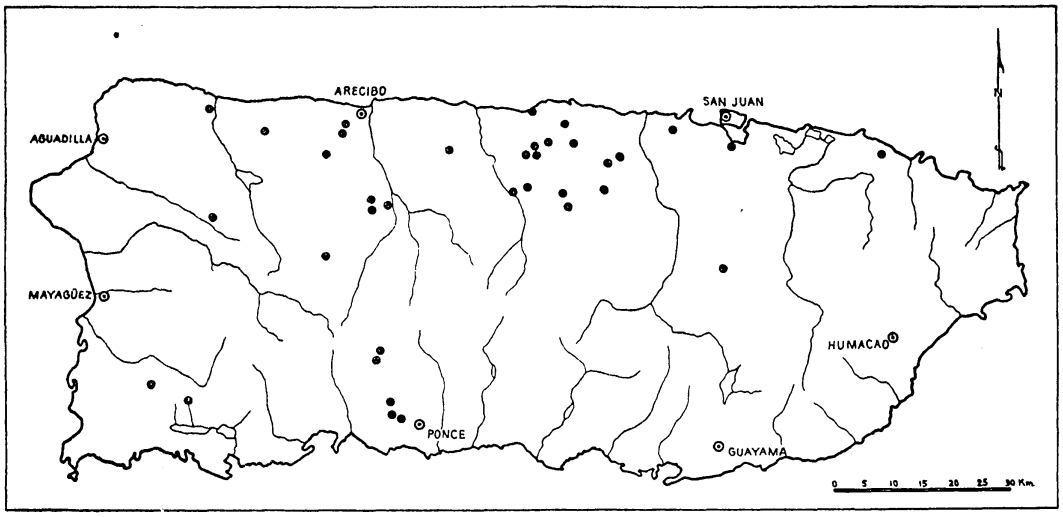

MAP 12. Distribution of *Pupisoma minus*.

## *Pupisoma dioscoricola* (C. B. Adams)

(Pl. III, Fig. 2)

*Helix dioscoricola* C. B. Adams, *Proc. Boston Soc. Nat. Hist.*, II (1845): 16.
*Zonites dioscoricola* Tryon, *Manual of Conchology*, 2 (1886): 74, Pl. 53, Figs. 46, 47.
*Thysanophora dioscoricola* C. B. Adams, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 371.
*Pupisoma dioscoricola* (C. B. Adams) Pilsbry, *Manual of Conchology*, 26 (1920): 36–39.

This is one of the most prevalent of the small species in Puerto Rico. It is invariably associated with *Thysanophora plagioptycha*, inhabiting a broad band across the northern coastal plain and a part of the coastal plain and foothills of the southwestern part of the island (Map 13). Apparently,




MAP 13. Distribution of *Pupisoma dioscoricola*.

but few records establish it as common to Puerto Rico. Pilsbry cited (1920–21: 36–37) many localities: from Florida to Yucatan, Costa Rica, and the Canal Zone southeast to Brazil; eastward through Jamaica, Haiti, and Santo Domingo. The whole range is very broken, indicating a definite need for careful search throughout the intervening regions. Although few details about its specific ecological demands are available from the work done in Puerto Rico, several authors have reported that this species lives normally on leaves of trees.

## *Vertigo hexodon* C. B. Adams

*Pupa hexodon* C. B. Adams, *Contributions to Conchology*, 1849, p. 37.
*Vertigo hexodon* Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 372.
*Vertigo ?ovata* Say, Pilsbry, *Manual of Conchology*, 25 (1919): 86–87.

Originally, *V. hexodon* was described by C. A. Adams (1849: 37) as from Jamaica. When Shuttleworth (1854: 53) gave his account of the mollusks collected by Blauner in Puerto Rico he reported this animal from the region of Humacao, where it was found rarely under leaves and in moss.

In his report of the land and fresh-water shells of Puerto Rico, E. von Martens (1877: 356) listed it among the species taken by Blauner, but preceded it with a question mark as belonging possibly with *Gastrocopta pellucida*. Dall and Simpson (1901: 372) merely listed it and gave no opinion regarding its status. Pilsbry (1918–20: 86–87) in monographing the genus *Vertigo* considered *hexodon* among forms provisionally referred to *V. ovata*. In discussing *hexodon* he stated (1918–20: 87):

> Three specimens from Humacao, Porto Rico (pl. 13, fig. 16), similar to *V. ovata* in color and surface, are small, length 1.7, diam. 1.15 mm., with 4⅔ whorls. There are weak infrapalatal nodules in two of them, all having a suprapalatal. None has an infraparietal lamella. Possibly this and the preceding forms are separable as subspecies, but the material seen is insufficient for a decision.

Whether *V. hexodon* or *V. ovata* is in Puerto Rico remains an open question. A careful search along the east shore of the island might be profitable. It is interesting that Pilsbry (1933: 161) reported *Vertigo milium* (Gould) in beach drift at Monte Cristi on the neighboring island of Santo Domingo.

## *Pupoides nitidulus* (Pfeiffer)

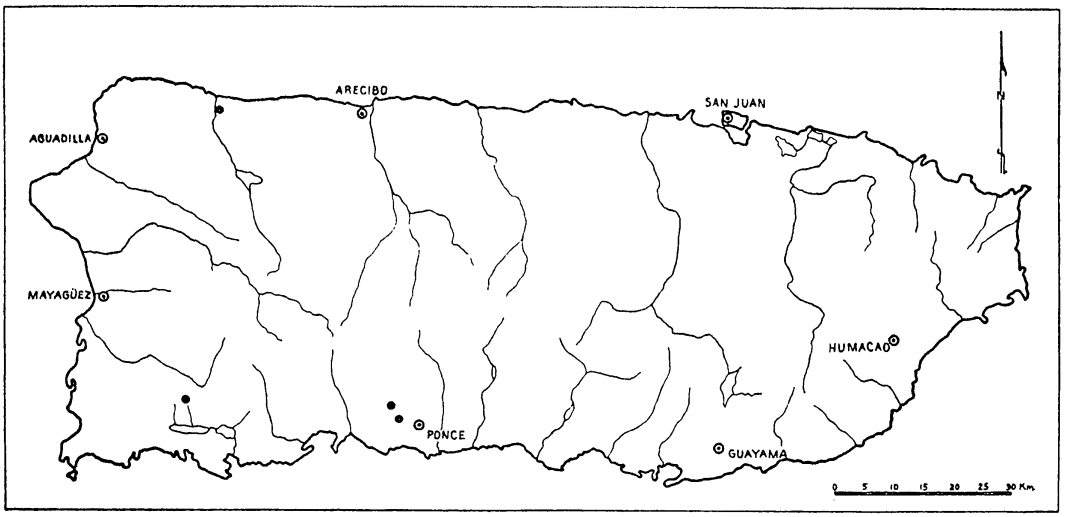
(Pl. III, Fig. 4)

*Bulimus nitidulus* Pfeiffer, *Wiegmann's Archiv f. Naturg.*, I (1839): 352.

*Pupoides marginatus* (Say), Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 372.

*Pupoides marginatus nitidulus* (Pfeiffer) Pilsbry, *Manual of Conchology*, 26 (1921): 113–14.

Shuttleworth (1854: 137) and Crosse (1892: 22) both assumed that this species was specifically distinct from what has been known as *P. marginatus* (Say). Dall and Simpson (1901: 372) pointed out that the description and the figure given for it clearly indicated that *P. nitidulus* is a synonym for




MAP 14. Distribution of *Pupoides nitidulus*.

*P. marginatus.* Since Say's name is preoccupied, Pfeiffer's name will be applied to this species.

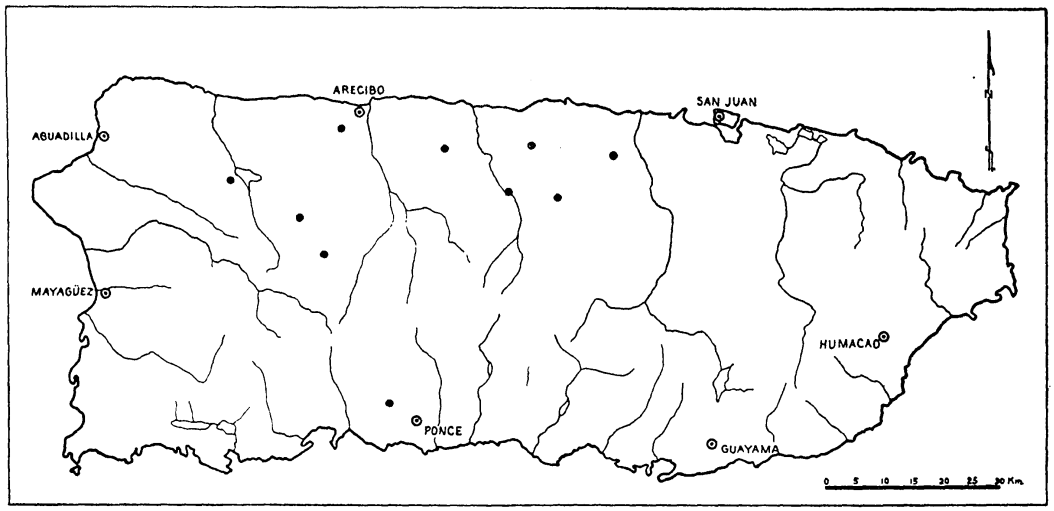
*P. nitidulus* in Puerto Rico appears to be confined to the coastal regions of the island (Map 14). Blauner's specimens were collected near Fajardo along the northwestern coast of the island. The present distribution pattern of *P. nitidulus* suggests that it was probably introduced into the island at least in three distinct and widely separated regions: Ponce, Quebradillas, and Fajardo.

## *Bothriopupa tenuidens* (C. B. Adams)

(Pl. III, Fig. 3)

*Pupa tenuidens* C. B. Adams, *Proc. Boston Soc. Nat. Hist.*, 1845, p. 15.
*Bothriopupa tenuidens* (C. B. Adams), Pilsbry, *Manual of Conchology*, 24 (1917): 229–30.

Members of this genus are readily recognized by the characteristic fine granulose or densely pitted surface of the shell, as is shown in the figure of a specimen collected in Puerto Rico. Previously, this species was not reported from this island. According to Pilsbry (1916–18: 229), there are records from Jamaica, Cuba, and Venezuela. Consequently, its occurrence in Puerto Rico is not surprising. *B. tenuidens* (Map 15) appears to be




MAP 15. Distribution of *Bothriopupa tenuidens.*

restricted to the limestone knolls and outcrops of the northern coastal plain and to similar limestone regions of the southern coastal plain. Although much less abundant, the distribution pattern is somewhat similar to that of *Gastrocopta servilis.* Available records indicate that *B. tenuidens* is absent from the main ridge of the Cordillera Central as well as from the eastern part of the island.

Ecologically, there is opportunity for study of the habitat requirements of this small species. The series taken were found near rather dry and

porous limestone exposures characteristic of the haystack knolls along the northern coastal plain. The material taken was largely aestivating in the soil, but the animals, when active, are reported to be on leaves.

## *Gastrocopta servilis* (Gould)

(Pl. III, Fig. 5)

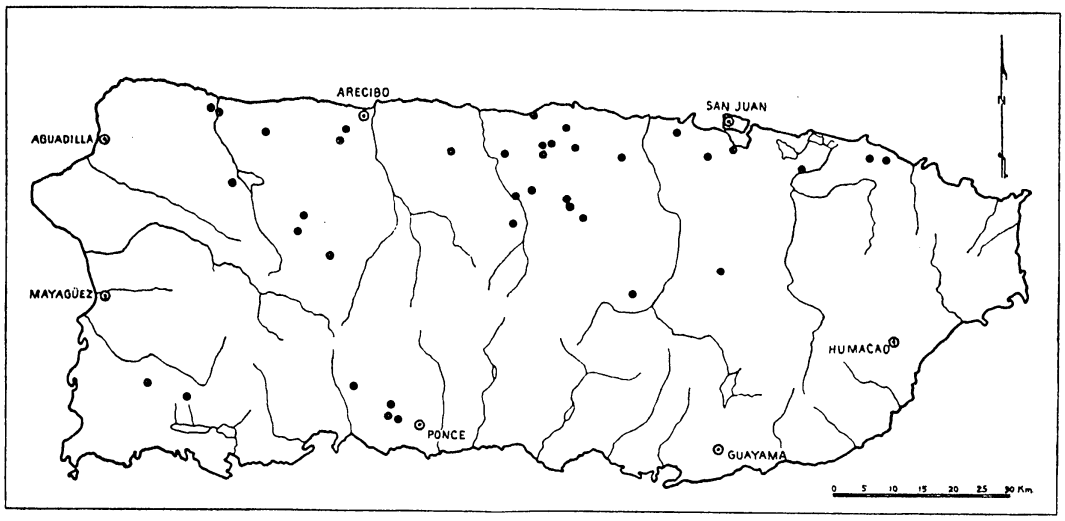
*Pupa servilis* Gould, *Boston Journ. Nat. Hist.*, 4 (1843): 356, Pl. 16, Fig. 4.
*Pupa riisei* Pfeiffer, *Zeitschr. f. Malak.*, 1852, p. 151.
*Gastrocopta servilis* (Gould) Pilsbry, *Manual of Conchology*, 24 (1916): 70–74.
*Gastrocopta servilis riisei* (Pfeiffer), Pilsbry, *Manual of Conchology*, 24 (1916): 74–75.

R. J. Shuttleworth (1854: 144) in his list of Puerto Rican shells included this species and indicated that it had a wide distribution in the Antilles. E. von Martens (1877: 356), who reported on the collections made by Gundlach and Krug, did not list *G. servilis*, but added it on the strength of Shuttleworth's paper in which Fajardo, Ceiba, and Humacao are given as eastern records. Pilsbry (1916–18: 70–75) stated:

> One of the commonest Antillean species. It was well described by Gould, but subsequently was for a long time merged into a group of forms known collectively as *Pupa pellucida*. Dr. Pfeiffer seems to have initiated this lumping, in which he was followed by Binney and many other authors. It is certainly related to *P. pellucida*, but differs by being constantly larger and generally of darker color.

It is possibly because of this merging of *G. servilis* with *G. pellucida* that Dall and Simpson (1901: 372) did not list *G. servilis*, although they did report *G. pellucida* in Puerto Rico.

*G. servilis* (Map 16) was common in Puerto Rico and was confined largely to the lowlands of the north and south coastal plains. Usually, *G. servilis* and *G. pellucida* were together in those rich limestone regions. However, the map showing the distribution of these species indicates that *G. servilis*




MAP 16. Distribution of *Gastrocopta servilis*.

has a considerably wider range southward across the northern half of the island. The absence of any *Gastrocopta* in the main mountain mass of Puerto Rico is especially noteworthy.

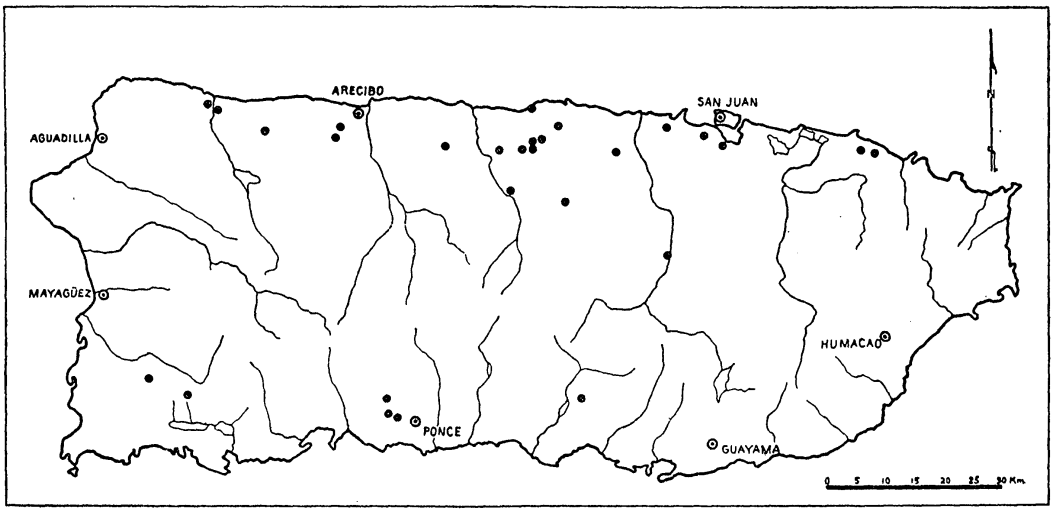
Where *G. servilis* and *G. pellucida* occur together they are readily separated, as previously pointed out by Pilsbry, by the consistent differences in size and color. After the removal of the larger and darker *G. servilis* from the smaller and lighter *G. pellucida,* there are usually a series of minor variations within each species.

## *Gastrocopta pellucida* (Pfeiffer)

(Pl. III, Fig. 6)

*Pupa pellucida* Pfeiffer, *Symbolae ad historiam Heliceorum,* I (1841): 46.
*Gastrocopta pellucida* (Pfeiffer), Pilsbry, *Manual of Conchology,* 24 (1916): 75–78.

This species and the preceding one are often associated with one another in the same habitat, attached to the lower surfaces of pieces of wood and on the damp lower part of leaves and stones. As already suggested, *G. pellucida* appears to be restricted to a narrower band across the northern coastal plain (Map 17). During the limited time devoted to this work it




MAP 17. Distribution of *Gastrocopta pellucida.*

was impossible to ascertain the probable ecological reasons, if any, for this restriction in the range of *G. pellucida.* H. B. Baker contributed these additional records: near Humacao Playa, east of Guanica Harbor, and two miles south of the town of Cabo Rojo. Evidently, the range of this animal may extend farther east and south along the coastal plains as far as Humacao.

Reference has already been made to Pilsbry's analysis of essential characters which will help in separating *G. pellucida* from *G. servilis.* Emphasis is placed on the uniformly smaller size, the light grayish rather than brown-

ish cast of the shell, and the bifid anguloparietal tooth in the aperture of the shell of *G. pellucida.*

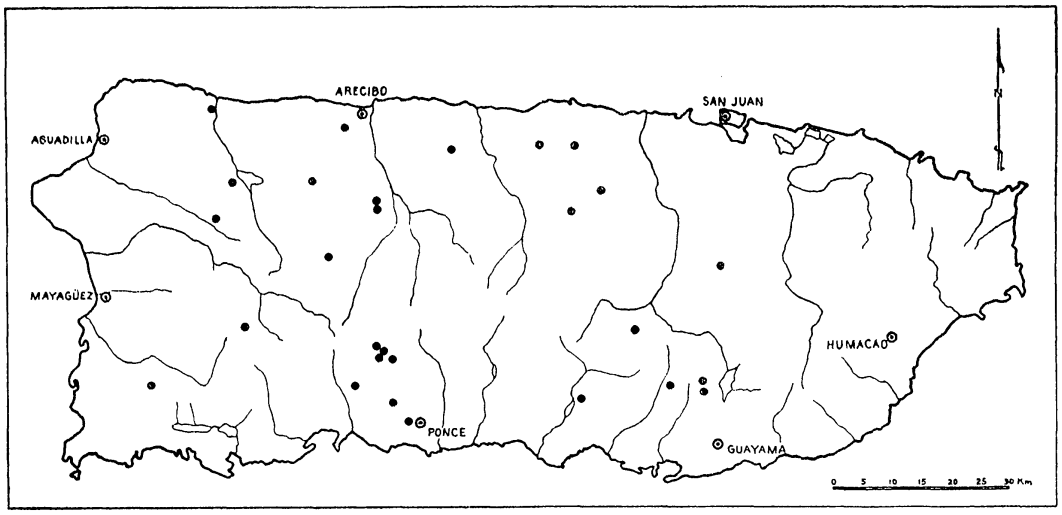
FAMILY SUCCINEIDAE

## *Succinea approximans* Shuttleworth

(Pl. IV, Fig. 1)

*Succinea approximans* Shuttleworth, "Diagnosen . . . ," 1854, p. 147.
*Succinea approximans* Shuttleworth, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 372.

Reported by Shuttleworth (1854: 147–48) and described by him. This species has a wide distribution (Map 18) in Puerto Rico. It is present




MAP 18. Distribution of *Succinea approximans.*

throughout the island, although it is more common in the coastal regions than it is in the central part. Blauner, who collected intensively in the eastern part of the island, found it at Fajardo, Luquillo, and Humacao. In his report on the collections made by Gundlach, von Martens (1877: 353) added Aquadilla and Las Marias to the records for western Puerto Rico.

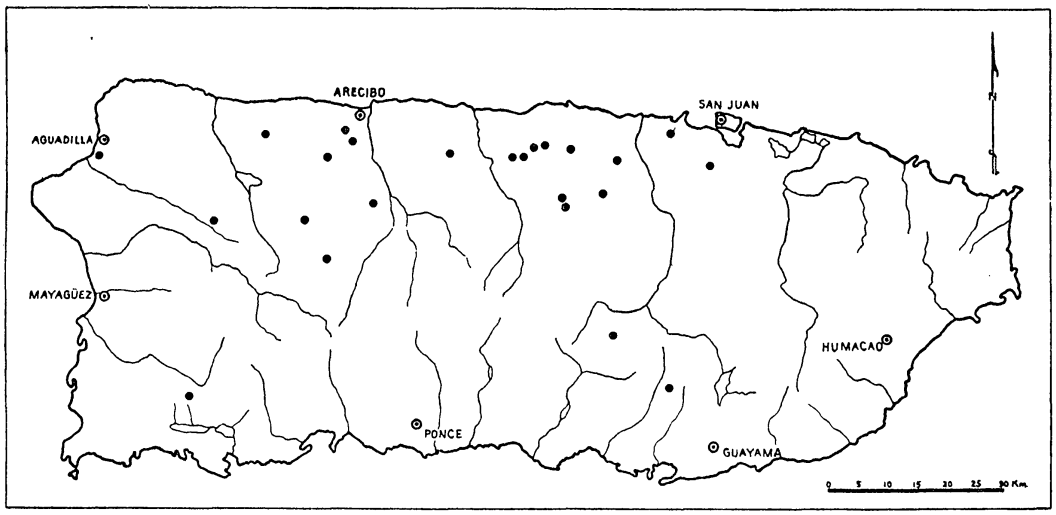
## *Succinea hyalina* Shuttleworth

(Pl. IV, Fig. 2)

*Succinea hyalina Shuttleworth,* "Diagnosen . . . ," 1854, p. 148.
*Succinea hyalina* Shuttleworth, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 372.

This species and *S. approximans* were described at the same time. Taxonomically, there is not a great difference between them. *S. hyalina* is usually shorter, with the last whorl considerably more swollen than that of *S. approximans.*

*S. hyalina* (Map 19) has a somewhat different pattern in that it is pre-




MAP 19. Distribution of *Succinea hyalina.*

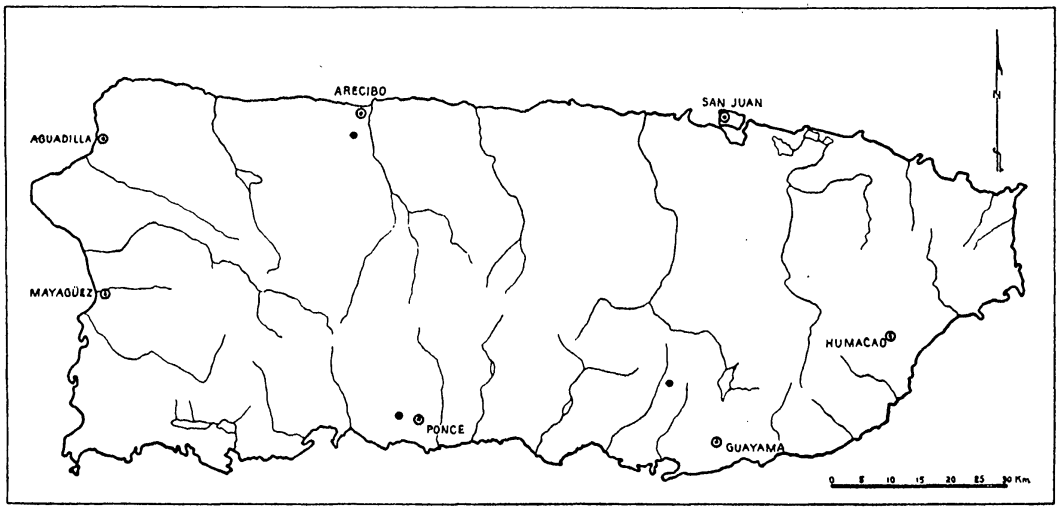
dominantly north-central and northwestern. It is but rarely found in the high mountain mass or on the southern coastal plain. The type lot came from the eastern part of the island near Rio Blanco, and it is reported as rare there by Shuttleworth.

## *Succinea riisei* Pfeiffer

(Pl. IV, Fig. 3)

*Succinea riisei* Pfeiffer, *Zeitschr. f. Malak.*, 10 (1853): 52.
*Succinea riisei* Pfeiffer, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 372.

This species is by far the rarest *Succinea* in Puerto Rico. Gundlach collected *S. riisei* near Quebradillas. Blauner failed to find it in eastern Puerto Rico. The distribution (Map 20) so far as can be determined from the few records available seems to indicate that *S. riisei* is confined to the




MAP 20. Distribution of *Succinea riisei.*

northern and southern coastal region. The pattern strongly suggests that this species might well have been introduced by some passive means since the advent of the white man. This robust, white species is readily distinguished from the other *Succinea* on the island. According to Pilsbry (1926*a:* 103), *S. riisei* may be related to the *S. avara* group. Pilsbry also suggested that there is an urgent need for an abundance of material from intermediate localities so that many of the nominal species in the *Succinea* group can be properly united or separated.

FAMILY HELICARIONIDAE

## *Guppya gundlachi* (Pfeiffer)

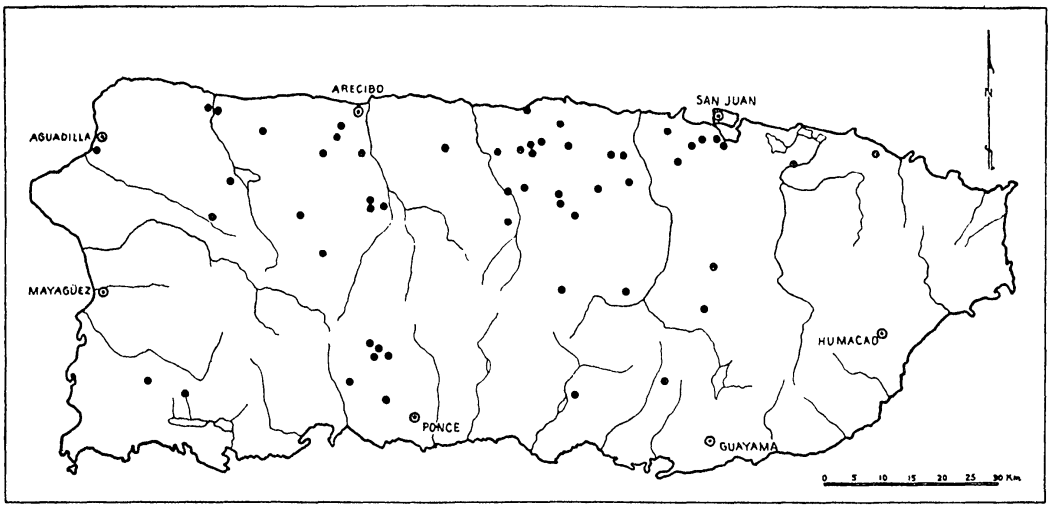
(Pl. III, Figs. 7*a*, *b*)

*Helix gundlachi* Pfeiffer, *Archiv f. Naturg.*, I (1840): 250.

*Guppya gundlachi* Pfeiffer, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 373.

*Guppya gundlachi* (Pfeiffer), H. B. Baker, "A Checklist of Nearctic Zonitidae," 1933, p. 2.

This is one of the most common of the small species in Puerto Rico (Map 21). Large numbers were taken, particularly among the limestone




MAP 21. Distribution of *Guppya gundlachi.*

haystack knolls of the northern coastal plain. In the high mountain regions *G. gundlachi* was much less common, although it was found at moderate altitudes such as in the regions of Barranquitas and on the approach to Adjuntas from the south. Blauner collected it along the eastern end of the island at Fajardo, Luquillo, Ceiba, and Humacao, but it was rare there. Evidently, Gundlach did not find the species named in his honor to be very common, since von Martens (1877: 346) gave but one specific locality (Quebradillas) in his report on Gundlach's work. The fine, spiral sculptural

lines on the shell of this smooth and glossy species makes identification of it relatively easy. Recently, H. B. Baker collected *G. gundlachi* from the following additional localities: dryish woods in the third line of hills, two miles south of Old Loiza; southeast side of Montoso (2000–2500 ft.); two miles southeast of Cabo Rojo; and agricultural station at Mayaguez. Regarding its ecology, Baker stated (in notes): "In leaf humus and weak climber, often in places modified by culture."

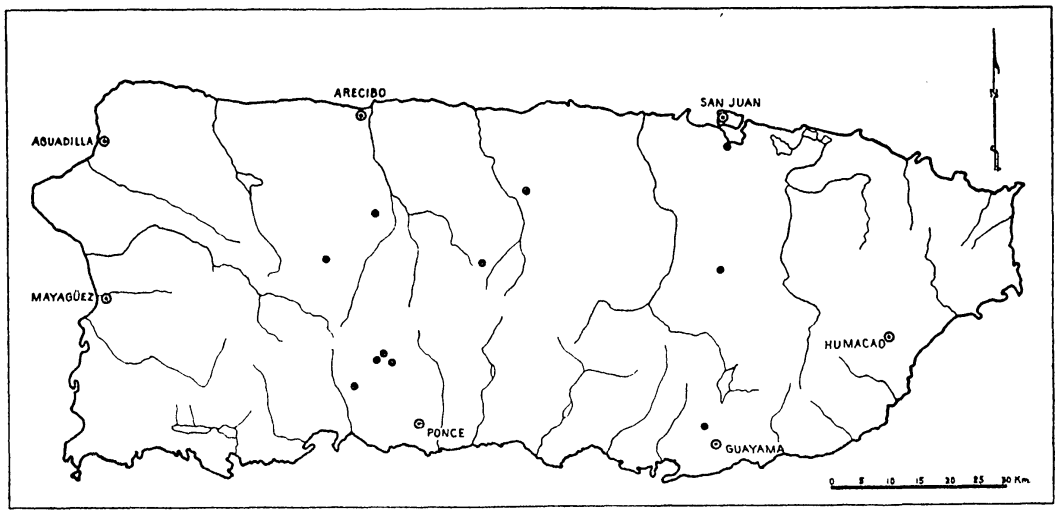
### *Habroconus* cf. *ernsti* (Jousseaume)

(Pl. III, Fig. 8)

*Ernstia ernsti* Jousseaume, *Mem. soc. zoöl. France*, 2 (1889): 251 (Venezuela).
*Habroconus* (*Ernstia*) *ernsti* (Jousseaume), H. B. Baker, *Proc. Acad. Nat. Sci. Phila.*, 80 (1928): 12.

It is not certain to which of the circum-Caribbean species of *Habroconus* this Puerto Rican material belongs. H. B. Baker recommended that it be tentatively referred to *H. ernsti*. By means of anatomical studies he plans later to examine the animals he collected in Puerto Rico so that the proper relations to related forms may be established.

The dozen lots of this species recorded (Map 22) are rather widely scat-




MAP 22. Distribution of *Habroconus* cf. *ernsti*.

tered throughout the island. Baker found his specimens "mainly in leaf humus." He gave the following additional records: Sierra de Bandera, along the Ponce-Adjuntas road; and Montoso. These animals appear to be most common in regions in which there is a reasonably thick natural cover.

## FAMILY ZONITIDAE

### *Hawaiia minuscula* (Binney)

(Pl. III, Fig. 9)

*Helix minuscula* Binney, *Boston Journ. Nat. Hist.*, 3 (1843): 345, Pl. 22, Fig. 4.

*Zonitoides minusculus* Binney, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 373.

*Hawaiia minuscula* (Binney) H. B. Baker, "A Checklist of Nearctic Zonitidae," 1933, p. 9.

Only three lots of *Hawaiia* were collected, thus indicating that *H. minuscula* is not at all common on this island. The localities established for it are: twelve kilometers southeast of Vega Baja, approaching Morovis; ten kilometers west of Utuado, along the road to Lares; and near caves about three kilometers southwest of Aguas Buenas. It is of interest that these stations are well back on the coastal plain near the northern border of the upper peneplain. The species appears to be distributed in a zone along the northern part of the island. It is difficult to formulate concepts about the distribution of a species as small as this one, because it may readily be overlooked in the course of field work. However, sufficient care has been taken in collecting among the limestone knolls of the northern coastal plain to suggest that it is not a usual species among them. Blauner presumably collected *H. minuscula* in the region of Fajardo and Humacao.

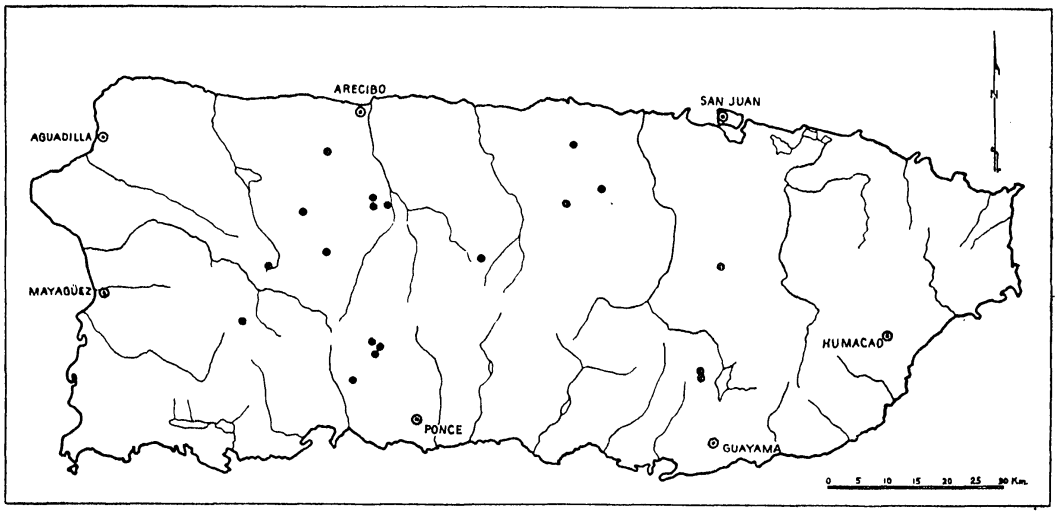
## *Retinella insecta* (von Martens)

(Pl. III, Figs. 10*a*, *b*)

*Hyalina insecta* E. von Martens, *Jahrb. d. deutsch. malak. Gesellsch.*, 4 (1877): 345, Pl. 12, Fig. 3.

*Vitrea insecta* von Martens, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 373.

This relatively common species in Puerto Rico inhabits (Map 23) the denser woodlands of the high mountain regions. It was originally collected by Gundlach near Utuado. It often occurs in the mountains among moss and vegetation covering limestone outcrops. Pilsbry and Vanatta (1927:




MAP 23. Distribution of *Retinella insecta*.

21) recorded it from Montoso, division of Mayaguez, at an elevation of 2624 feet.

There is some difference of opinion as to whether *R. insecta* differs essentially from the North American *R. indentata.* Bland (1875: 77) credited *R. indentata* to Puerto Rico. A few years later von Martens described *R. insecta,* and although he admitted it was closely related to *R. indentata,* he claimed specific distinction for it. The main difference between these two species, according to von Martens, is that *R. insecta* is much more flattened that is *R. indentata.* More recently, H. B. Baker (1930*a:* 210–11) has stated that *R. insecta* is nearest to *R. indentata paucilirata* (Morelet):

> Anatomical data will be necessary to determine the status of at least two peculiar forms in extreme southeastern United States. The 'Florida form,' which is usually perforate (or narrowly umbilicate) but tends to develop a considerably more corneous shell, may represent a distinct subspecies; it seems to approach closely Martens' Porto Rican *insecta* (ANSP. 141924; one shell from summit of Montoso, D. Mayaguez, P. R.) . . . .

At the present time the taxonomic status of this species is uncertain.

## *Retinella* sp. near *R. subhyalina* (Pfeiffer)

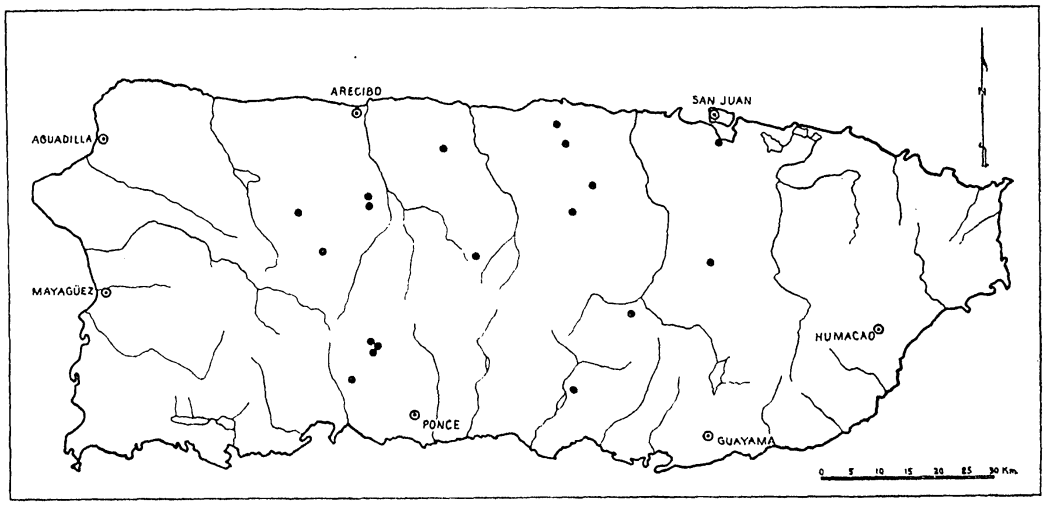
*Helix subhyalina* Pfeiffer, *Malak. Blätt.*, 14 (1867): 196.

*Retinella (Perpolita) subhyalina subhyalina* (Pfeiffer), H. B. Baker, *Proc. Acad. Nat. Sci. Phila.*, 82 (1930): 199.

*Retinella (Perpolita) subhyalina subhyalina* (Pfeiffer), H. B. Baker, "A Checklist of Nearctic Zonitidae," 1930, p. 24.

*Hyalinia subhyalina* Pfeiffer, H. Strebel, and Georg Pfeffer, *Beitrag . . . mex. Land- u. Süsswasser Conch.*, 4 (1880): 18, Taf. 4, Fig. 14 (one of few figures of this species). Several lots (Map 25) found were confused with *Zonitoides arboreus.*

This species is figured by Strebel and Pfeffer (1880: 18), and it is best known as belonging to the region of Mexico. H. B. Baker (1930*a:* 199)




MAP 24. Distribution of *Retinella subhyalina.*

stated: "On account of its gradually expanded whorls and corneous, spirally striate shell, this species is quite easily confused with *Zonitoides arboreus* (Say). But, *R. subhyalina* is a smaller shell with more depressed whorls, shallower suture and more open umbilicus."

In Puerto Rico, Baker collected it south of Cataño, in the Sierra Morales, at Adjuntas, and at Montoso; under leaves on the ground. This and the preceding species are often in wooded areas throughout the central and higher parts of the island. It was especially common in moist situations among dense vegetation covering limestone outcrops. The distribution (Map 24) indicates that *R. subhyalina* is a relatively common species in the central higher parts of the island.

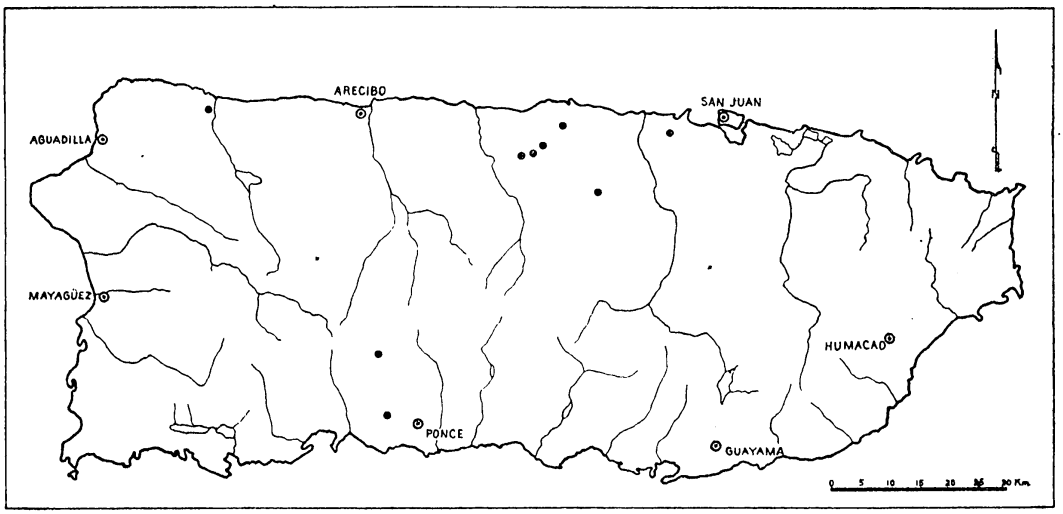
## *Striatura meridionalis* (Pilsbry and Ferriss)

(Pl. III, Fig. 11)

*Vitrea milium meridionalis* Pilsby and Ferriss, *Proc. Acad. Nat. Sci. Phila.*, 58 (1906): 152.

*Striatura (Pseudohyalina) meridionalis* (Pilsbry and Ferriss), H. B. Baker, "A Checklist of Nearctic Zonitidae," 1933, p. 10.

This minute species has not previously been reported from Puerto Rico. It was common only along the limestone margin of the northern and southern coastal plain (Map 25). Its presence in and near the sugar growing regions




MAP 25. Distribution of *Striatura meridionalis.*

suggests that it may have been introduced into the island accidently with agricultural products. The failure of Blauner and Gundlach to find it may mean that it was not in Puerto Rico when they carried on their work there. Since *S. meridionalis* is among the smallest of shells, however, there is always the possibility that it may have been overlooked hitherto. H. B. Baker kindly examined specimens and in a letter regarding this matter

stated: "Your three lots of *Striatura meridionalis* have been compared with Mexican specimens, from which they appear to differ only in lacking ¼ to ½ whorl; so they are smaller."

### *Zonitoides arboreus* (Say) + *Helix bryodes* Shuttleworth

(Pl. III, Figs. 12*a*, *b*)

*Helix arboreus* Say, "Conchology," *Nicholson's British Encyclopedia*, 1st Amer. ed., 1816.
*Zonites bryodes* Shuttleworth, "Diagnosen . . . ," 1854, p. 128.
*Zonitoides* (*Zonitellus*) *arboreus* (Say), H. B. Baker, "A Checklist of Nearctic Zonitidae," 1933, p. 13.

Apparently, Shuttleworth's *Helix bryodes* is a synonym of *Zonitoides arboreus*. Baker called my attention to this relationship. He collected specimens at Montoso and west of Santa Ana Peak. Shuttleworth's collections were from Luquillo, and San Juan; von Martens reported it from Caguana, west of Utuado. There is a strong possibility that this species has been introduced. Only five lots were taken in my own collecting from the following localities: near Peñuelas; about twenty-four kilometers south of Arecibo; about fifteen kilometers south of Arecibo; about nineteen kilometers east of Arecibo; and near caves about three kilometers southeast of Aguas Buenas. Only single specimens were found at all five of these stations.

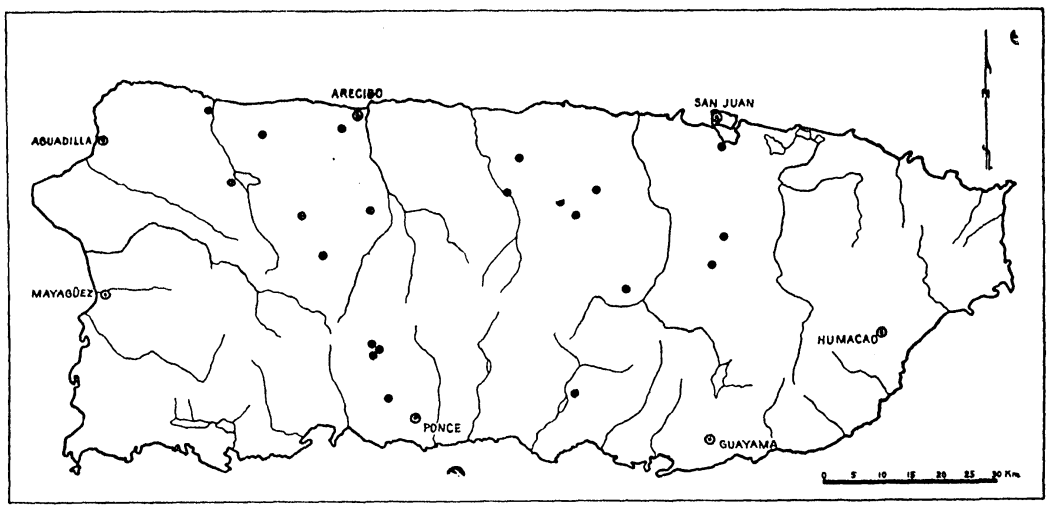
## FAMILY SYSTROPHIIDAE

### *Miradiscops* sp.

(Pl. IV, Fig. 4)

*Miradiscops* H. B. Baker, *Occ. Papers Mus. Zool. Univ. Mich.*, 156 (1925): 15, 17, 34.
*Miradiscops* H. B. Baker, *Proc. Acad. Nat. Sci. Phila.*, 81 (1929): 252.

The specific status of this group in Puerto Rico is uncertain. Some twenty-one stations are established (Map 26) for it. H. B. Baker, who




MAP 26. Distribution of *Miradiscops*.

worked with species of this genus, which ranges from Mexico to northern South America, has informed me that he is planning to make a careful study of the variable shells of series he has collected in Puerto Rico. Throughout the island *Miradiscops* has a wide range of habitat conditions, although there does seem to be a preference for limestone outcrops in the northern and southern coastal plain regions. There are few records for it along the high, igneous, and heavily wooded region of the Cordillera Central.

## *Cecilioides gundlachi* (Pfeiffer)

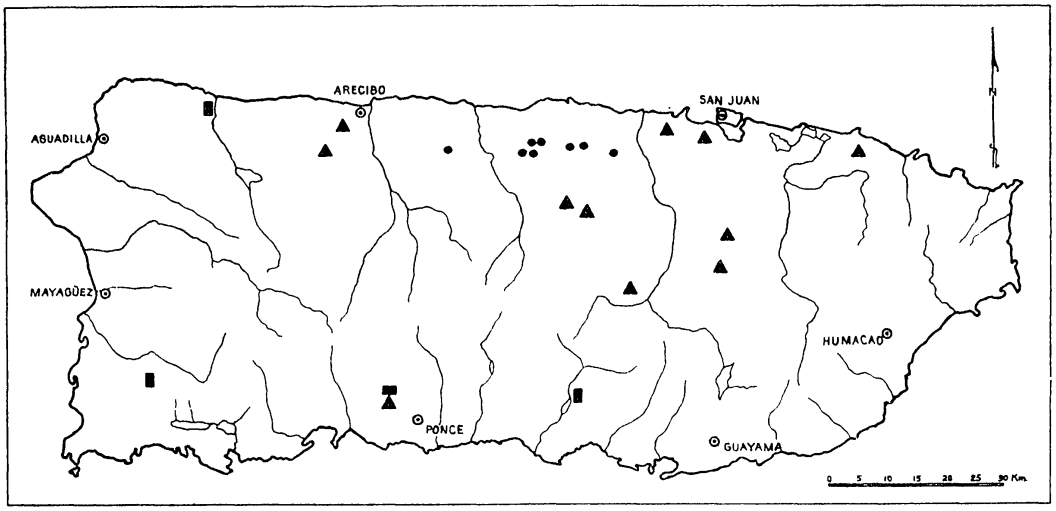
(Pl. IV, Fig. 5)

*Achatina gundlachi* Pfeiffer, *Zeitschr. f. Malak.*, 1850, p. 80.

*Caecilioides* (*Geostilbia*) *gundlachi* (Pfeiffer), Pilsbry, *Manual of Conchology*, 20 (1910): 43–45.

*Cecilioides* (*Geostilbia*) *gundlachi* (Pfeiffer), Pilsbry, *Proc. Acad. Nat. Sci. Phila.*, 82 (1930): 352 (Panama).

These shells are among the smallest found in Puerto Rico, which may account for the fact that, so far as can be determined, *C. gundlachi* has not




MAP 27. Distribution of *Zachrysia auricoma havanensis* (circles), *Cecilioides gundlachi* (triangles), and *Cecilioides consobrinus* (rectangles).

hitherto been reported from this island. Apparently, the species is widely distributed throughout the islands of the West Indies. Pilsbry (1910: 43) gave records for several of the islands in the Greater and Lesser Antilles, but did not include either Hispaniola or Puerto Rico. In this island, *C. gundlachi* was confined more or less to a broad band across the northern shore. Its occurrence seems (Map 27) sporadic, but this may be due to faulty methods of collecting such minute forms. Although the species was found at moderate elevations approaching Barranquitas, it was never observed in the high mountainous region of the interior.

## *Cecilioides consobrinus* (D'Orbigny)

(Pl. IV, Fig. 6)

*Achatina consobrina* D'Orbigny, "Moluscos," *in* De la Sagra, *Histoire physique . . . , et naturelle de l'île de Cuba,* 1 (1855): 170, Pl. xi *bis,* Figs. 7, 9.
*Caecilioides consobrina* (D'Orbigny) Pilsbry, *Manual of Conchology,* 20 (1910): 39–42.

The smaller size of *C. consobrinus* as compared to *C. gundlachi* enables one to separate readily the two species when they are found at the same station. This species averages about 2 mm. in length, whereas *C. gundlachi* is about twice or more as long. In Puerto Rico, *C. consobrinus* is somewhat restricted to the coastal plain of the southwestern part of the island; there is only a single record for the extreme western portion of the northern coastal plain (Map 27). More careful search is necessary to delimit its range exactly, although there is reason to believe that *C. consobrinus* is mainly a species of the southwestern coastal plain and that *C. gundlachi* inhabits chiefly the northern part of the island, spreading well into the foothills.

Studies of this genus by European observers (see Pilsbry, 1910: 2–5) have yielded some interesting observations regarding its method of progression, the extreme flexibility and elastic nature of the animal, its unique, colorless eye, which led Lamarck to believe *Cecilioides* was eyeless, and the tendency of this group to inhabit graves. Such observations suggest that further studies of these unusually small and secretive animals in a region like Puerto Rico might prove extremely interesting. Hugh Watson (1928: 217–43) has presented a most interesting account of the anatomy of *Cecilioides acicula,* emphasizing that the structure of the various organs is correlated with the functions of those organs conforming to conditions in its subterranean environment. In a consideration of the geographical distribution of *Cecilioides,* Watson stated: "But this does not explain the presence of *Ceciliodes* in Central America and the West Indies, which is almost certainly due to the genus having been evolved before the New World was completely cut off by the Atlantic Ocean."

### FAMILY FERUSSACIIDAE

## *Opeas pumilum* (Pfeiffer)

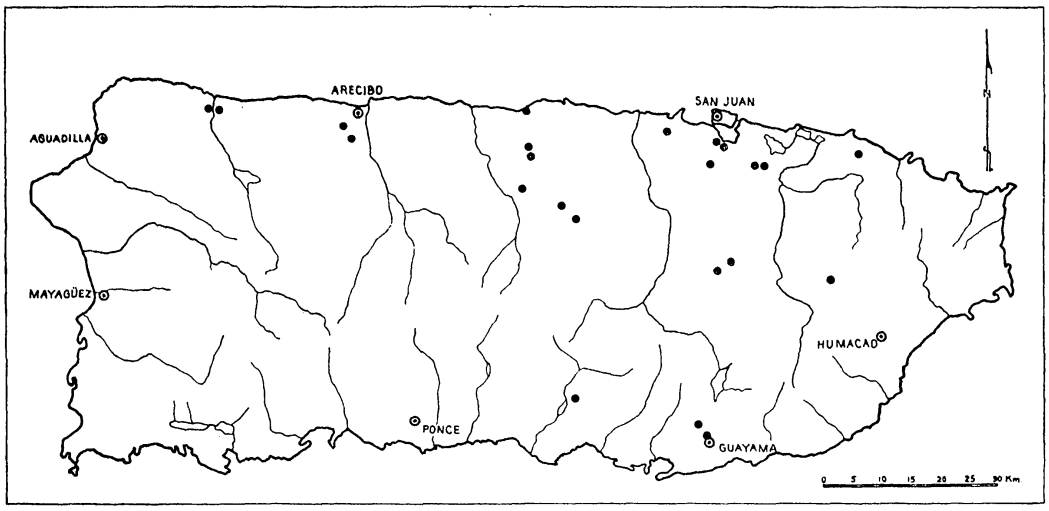
(Pl. IV, Fig. 7)

*Helix goodalli* Miller, *Ann. Phil.,* 7 (1822): 381, *non* Férussac, 1821.
*Bulimus clavulus* Turton, *A Manual of the Shells of the British Isles,* 1831, *non* Lamarck, 1822.
*Bulimus pumilus* Pfeiffer, *Wiegmann's Archiv f. Naturg.,* II (1840): 252.
*Opeas goodalli* Miller, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 375.
*Opeas goodalli* (Miller), Pilsbry, *Manual of Conchology,* 18 (1906): 200–203.
*Opeas pumilum* (Pfeiffer), Pilsbry, *Nautilus,* 24 (1910): 31.

Pilsbry (1906: 202) commented on this form:

This wide-spread little species was originally described from a colony found around 'pines' in Bristol, England. Since '*Bromelia*' *bracteata*, imported from Jamaica in 1785, was the only species of pineapple at that time cultivated in England, it is likely that the original stock of *goodalli* came in dirt around the roots, and from Jamaica; though the ultimate habitat of the pineapple was probably Brazil, a country equally inhabited by the *Opeas*. The snail is said to have first been observed about 1816. It is now found in many hothouses in England, around London, Manchester, etc. It has also been imported into various tropical countries, and will doubtless attain as wide a range as *Subulina octona* and *Opeas gracile* in time.

In Puerto Rico *O. pumilum* (Map 28) has somewhat the same distributional range as have *Lamellaxis gracilis* and *Lamellaxis micra*. It seems




MAP 28. Distribution of *Opeas pumilum*.

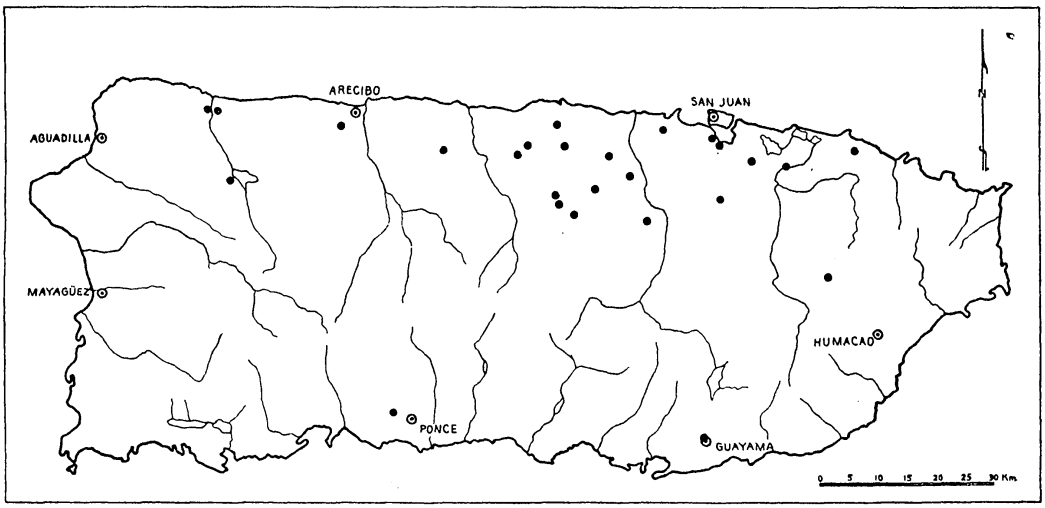
to be most common in the eastern half of the island, where it is present in the cultivated parts of the coastal plain and within the deeply incised valley in the vicinity of Caguas and Juncos.

## *Lamellaxis gracilis* (Hutton)

(Pl. IV, Fig. 11)

*Bulimus gracilis* Hutton, *Journ. Asiatic Soc. Bengal*, 3 (1834): 84, 93.
*Achatina subula* Pfeiffer, *Archiv f. Naturg.*, I (1839): 352.
*Stenogyra subula* Binney, A *Manual of American Land Shells*, 1885, p. 425, Fig. 473.
*Opeas subula* Pfeiffer, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 374.
*Opeas gracile* (Hutton), Pilsbry, *Manual of Conchology*, 18 (1906): 198–200.

The distribution of this species in Puerto Rico is practically the same as that of *L. micra*. In the field the two species often occur together. According to the distribution records (Map 29), however, *L. gracilis* is somewhat more common than is *L. micra*. There seems to be a wider and heavier concentration of *L. gracilis* in the northeastern part of the island. Along the southern coastal plain this species seems to have been introduced at both




MAP 29. Distribution of *Lamellaxis gracilis.*

Ponce and Guayama. Pilsbry stated (1906: 199) that *O. subula* Pfeiffer is a synonym of *L. gracilis.*

## *Lamellaxis micra margaritaceus* (Shuttleworth)

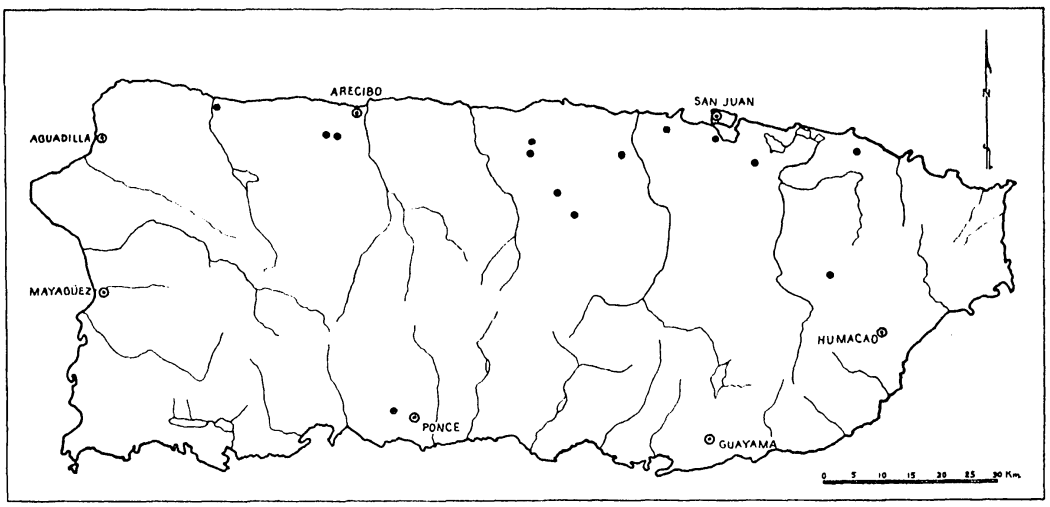
(Pl. IV, Fig. 12)

*Stenogyra* (*Opeas*) *margaritacea* Shuttleworth, "Diagnosen . . . ," 1854, p. 139 (unfigured).

*Opeas margaritaceus* Shuttleworth, Dall and Simpson, "The Mollusca of Porto Rica," 1901, p. 375.

*Opeas micra margaritaceum* (Shuttleworth), Pilsbry, *Manual of Conchology,* 18 (1906): 196.

In Puerto Rico *L. micra* was most common along the drier limestone regions of the northern coastal plain (Map 30). Shuttleworth described his




MAP 30. Distribution of *Lamellaxis micra margaritaceus.*

*Stenogyra margaritacea* from Rio Blanco, which is near the present town of Naguabo at the east end of the island. Pilsbry (1906: 196) decided after examining topotypes (?) to permit *O. margaritaceus* to stand as a variety under *O. micra*. The specimens of *L. micra* collected were most common among limestone outcrops in the cultivated and populated regions of the northern shore region. The single lot taken west of Ponce may have been introduced. More thorough collections are necessary to establish the exact limits of its range in this island.

## *Lamellaxis monodon opalescens* (Shuttleworth)

(Pl. IV, Fig. 8)

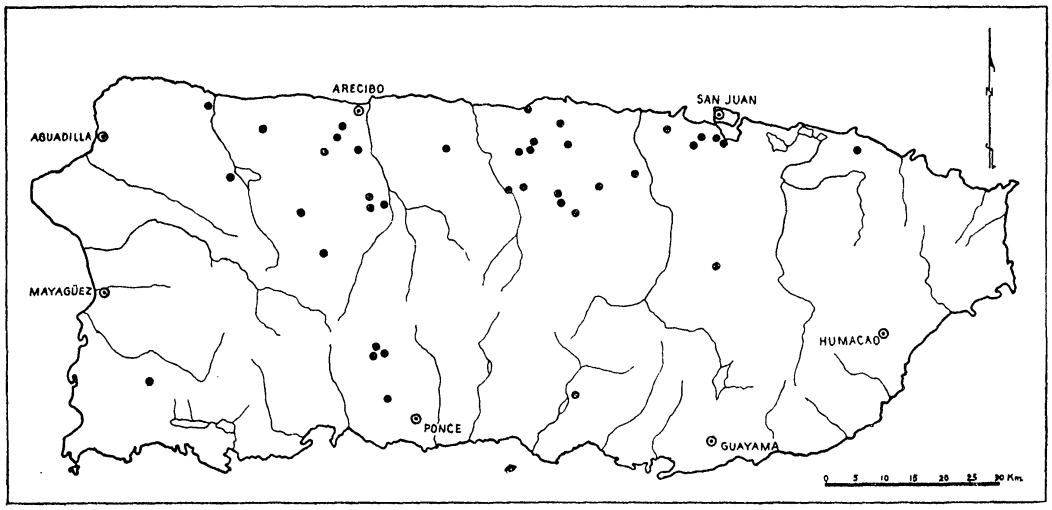
*Leptinaria opalescens* Shuttleworth, "Diagnosen . . . ," 1854, p. 142.

*Leptinaria opalescens* Shuttleworth, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 374.

*Leptinaria monodon opalescens* Shuttleworth, Pilsbry, *Manual of Conchology,* 18 (1906): 293–94.

The members of the former *Leptinaria* group are difficult to determine. Those in Puerto Rico are no exception. The determinations used here are based on the work of H. A. Pilsbry (1906: 284–96). He has stated (1906: 286) in a discussion under *Leptinaria:* "The species are numerous, many of them critical and difficult to diagnose; and the more widely distributed forms have been herein reduced to synonyms; but I have in each case given evidence for my views. . . ."

Shuttleworth (1854: 142) recorded three species from eastern Puerto Rico. Pilsbry (1906: 293) stated that Shuttleworth's *L. stylodon* "cannot be separated even varietally from the Jamaican *L. monodon.* The supposed differences indicated by Shuttleworth are of little importance." Thus, *L. stylodon* becomes a synonym of *L. monodon.* Another of Shuttleworth's




MAP 31. Distribution of *Lamellaxis monodon opalescens.*

species, *L. opalescens,* is considered by Pilsbry as a variety of *L. monodon.* It is interesting in this connection that H. B. Baker in notes kindly submitted suggested that he does not feel that the variety *L. opalescens* is "much good." All of which brings out the fundamental truth originally stated by Pilsbry, which emphasizes that careful studies are needed before one can evaluate properly the species within this group.

The specimens from Puerto Rico placed under this specific heading have the characters essentially belonging to this group as defined by Pilsbry: lacking a parietal lamella and having an ovate shell ($5\frac{1}{2}$ to $6\frac{1}{2}$ whorls), with the diameter of the shell about one-half of its length. The *L. monodon* specimens (Map 31) were largely confined to the coastal plain and foothills of the north and south coast. Although the species attained considerable altitude, it was decidedly scarce in the main mountain mass. Shuttleworth reported that Blauner collected it at Humacao, which extends the range considerably to the southeast.

### *Lamellaxis paludinoides* (D'Orbigny)

*Achatina paludinoides* D'Orbigny, "Mollusques," *in* Sagra, *Histoire physique . . . , et naturelle de l'île de Cuba,* I (1841): 171, Pl. XI, Figs. 13–15.

*Spiraxis paludinoides* D'Orbigny, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 375.

### *Lamellaxis acicularis* (Shuttleworth)

*Stenogyra (Subulina) acicularis* Shuttleworth, "Diagnosen . . . ," 1854, p. 49.

*Subulina acicularis* Shuttleworth, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 375.

*Leptinaria acicularis* (Shuttleworth) Pilsbry, *Manual of Conchology,* 18 (1906): 299.

### *Lamellaxis alabastrina* (Shuttleworth)

*Stenogyra (Opeas) alabastrina* Shuttleworth, "Diagnosen . . . ," 1854, p. 139 (unfigured).

*Opeas alabastrinus* Shuttleworth, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 375.

*Opeas alabastrinum* (Shuttleworth), Pilsbry, *Manual of Conchology,* 18 (1906): 204–5.

### *Lamellaxis gompharium* (Shuttleworth)

*Stenogyra (Opeas) Gompharium* Shuttleworth, "Diagnosen . . . ," 1854, p. 139 (unfigured).

*Opeas gompharium* Shuttleworth, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 375.

*Opeas gompharium* (Shuttleworth), Pilsbry, *Manual of Conchology,* 18 (1906): 205.

### *Lamellaxis unilamellata* (D'Orbigny)

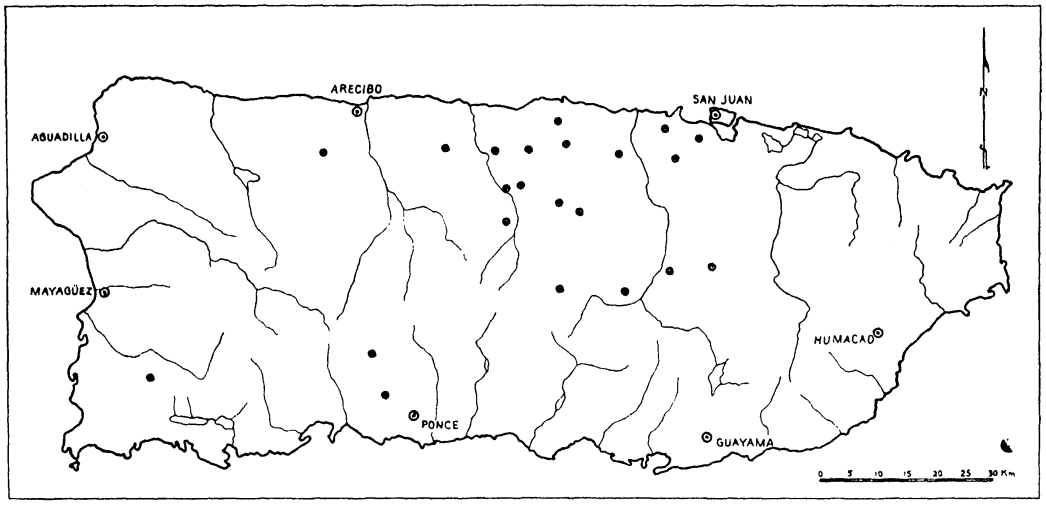
(Pl. IV, Fig. 13)

*Helix unilamellata* Férussac in coll.; D'Orbigny, *Mag. de zoöl.,* 1835, p. 9.

*Achatina lamellata* Potiez and Michaud, *Galerie des mollusques ou Catalogue . . . , mollusque et coquille du Muséum de Douai,* 1 (1838): 128, Pl. 11, Figs. 7, 8.

*Leptinaria lamellata* (Potiez and Michaud) Pilsbry, *Manual of Conchology,* 19 (1907): 288.

Shuttleworth (1854: 142) and Crosse (1892: 30) listed this species under the name *L. antillarum* Shuttleworth. Pilsbry (1906: 289) has shown that *L. unilamellata* has priority over *L. antillarum.* In distinguishing the two species formerly referred to *Leptinaria* and apparently found in Puerto Rico, there seems to be a consistent difference in size and shape between *L. monodon* and *L. unilamellata.* The former is usually about one-half as large and has a much more swollen and obtuse profile than the latter. Not only is *L. unilamellata* less common in Puerto Rico, but it appears to have a rather characteristic distribution pattern (Map 32). There appears to




MAP 32. Distribution of *Lamellaxis unilamellata.*

be a concentration of stations in the region of the haystack knolls and in the foothills immediately south of them in the north-central part of the island.

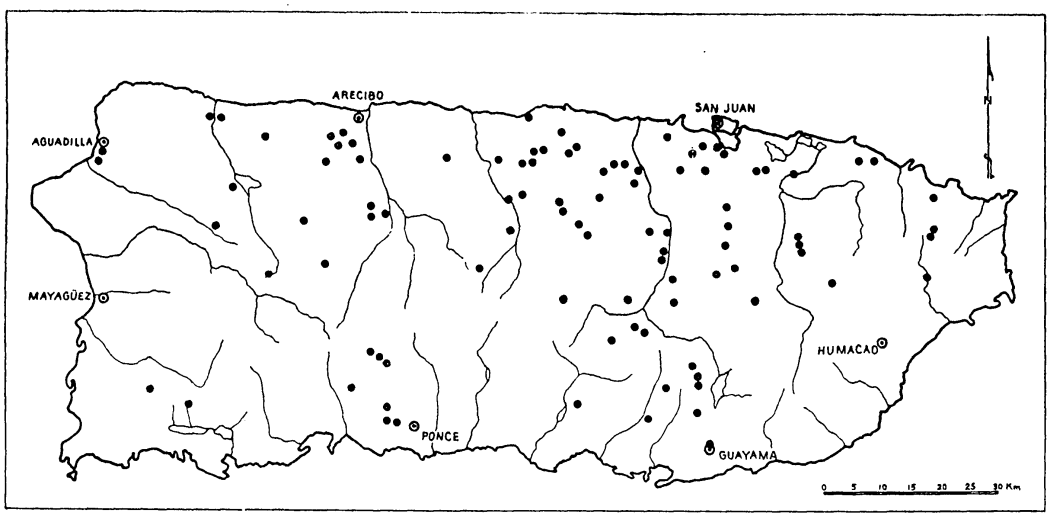
FAMILY SUBULINIDAE

## *Subulina octona* (Bruguière)

(Pl. IV, Fig. 14)

*Bulimus octona* Bruguière, *Tableau encyclopédique et méthodique,* 1 (1789): 325, No. 47.
*Subulina octona* Bruguière, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 375.
*Subulina octona* (Bruguière) Pilsbry, *Manual of Conchology,* 18 (1906): 72–74.

Both Blauner and Gundlach found this species to be very common in Puerto Rico. In more recent collections there were practically no localities in which *S. octona* was not represented (Map 33). It was usually more abundant in the densely populated and cultivated regions of the coastal plain and foothills, but was, nevertheless, well represented in some of the




MAP 33. Distribution of *Subulina octona.*

less accessible parts of the forested mountain regions. Pilsbry (1906: 74) believed that in nature *Subulina* is restricted to Africa and America but that through commerce *S. octona* has spread to the East Indies. It is unquestionably one of the most adaptable and widely distributed of tropical mollusks. C. Montague Cooke, Jr., (1926: 2279) stated:

> As an example of a snail distributed by modern commerce, let me mention *Subulina octona.* Up to 1887, Garrett knew this species only as an inhabitant of the West Indies. It was not known in Hawaii prior to 1903. Since 1920, specimens have come into the Bishop Museum Collection from Rapa, The Marquesas, Society Islands, Cook Islands, Samoa, Fiji, Tonga, and New Hebrides. In Tutuila, this is one of the most abundant species living today occurring in great abundance from the sea-shore to the crest of the mountains.

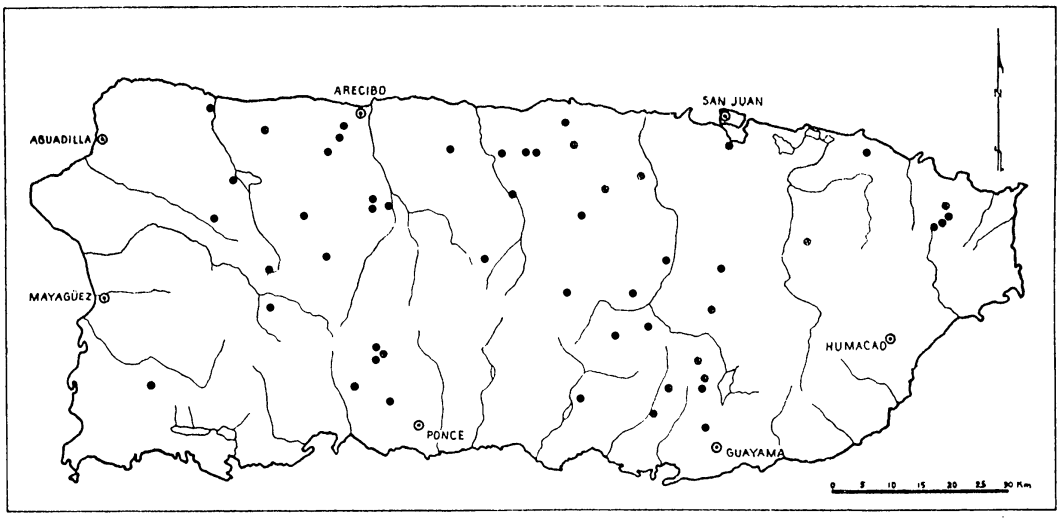
FAMILY ACHATINIDAE

## *Obeliscus terebraster* (Lamarck)

(Pl. IV, Fig. 9)

*Bulimus terebraster* Lamarck, *Histoire des animaux sans vertèbres . . .*, VI (1882): 124.
*Stenogyra terebraster* Lamarck, Dall and Simpson, "The Mollusca of Porto Rico," (1901), p. 374.

In Puerto Rico *O. terebraster* is widely distributed (Map 34). The species apparently grows to its maximum size and occurs most commonly in the mountainous regions of the island. On the coastal plain the snails become stunted. This gradual reduction in size is shown in Table III and Figure 3. For statistical purposes, it is difficult to obtain large series from the lower regions of the island, but the few specimens available in the lots taken on the coastal plain clearly show that *O. terebraster* is usually about one-half as large at the lower altitudes as are specimens taken in the Cordillera Central. This observation is of particular importance in that it




MAP 34. Distribution of *Obeliscus terebraster*.

stresses that among some species, such as this one, optimum living conditions are at the higher altitudes, and stunting proceeds to the forms living under the less favorable conditions of the coastal plains. In certain other species, such as *Megalomastoma croceum* and *Polydontes lima,* the stunting occurs in the reverse order, that is, the larger forms inhabit the lowland, and the dwarfed specimens are at higher elevations.

TABLE III

PERCENTAGE DISTRIBUTION FOR COLLECTIONS OF *Obeliscus terebraster*
Taken in Puerto Rico and allocated according to elevations.

| Length in mm. | –499′ | | 600′–1499′ | | 1500′– | | Totals | |
|---|---|---|---|---|---|---|---|---|
| 12 | 1 | 0.8 | ..... | ..... | ..... | ..... | 1 | 0.2 |
| 13 | 6 | 5.1 | 3 | 2.6 | ..... | ..... | 9 | 1.6 |
| 14 | 6 | 5.1 | 6 | 5.2 | 3 | 0.9 | 15 | 2.7 |
| 15 | 17 | 14.5 | 7 | 6.0 | 6 | 1.9 | 30 | 5.5 |
| 16 | 25 | 21.4 | 8 | 7.9 | 9 | 2.8 | 42 | 7.6 |
| 17 | 16 | 13.7 | 20 | 17.2 | 15 | 4.7 | 51 | 9.3 |
| 18 | 15 | 12.8 | 14 | 12.0 | 23 | 7.3 | 52 | 9.5 |
| 19 | 10 | 8.5 | 12 | 10.3 | 42 | 13.3 | 64 | 11.7 |
| 20 | 10 | 8.5 | 6 | 5.2 | 39 | 12.3 | 55 | 10.0 |
| 21 | 7 | 6.0 | 18 | 15.5 | 46 | 14.5 | 71 | 12.9 |
| 22 | 1 | 0.8 | 4 | 3.4 | 45 | 14.2 | 50 | 9.1 |
| 23 | 2 | 1.7 | 5 | 4.3 | 35 | 11.0 | 42 | 7.6 |
| 24 | 1 | 0.8 | 6 | 5.2 | 17 | 5.4 | 24 | 4.4 |
| 25 | ..... | ..... | 4 | 3.4 | 14 | 4.4 | 18 | 3.3 |
| 26 | ..... | ..... | 1 | 0.9 | 9 | 2.8 | 10 | 1.8 |
| 27 | ..... | ..... | 1 | 0.9 | 6 | 1.9 | 7 | 1.3 |
| 28 | ..... | ..... | 1 | 0.9 | 5 | 1.6 | 6 | 1.0 |
| 29 | ..... | ..... | ..... | ..... | 1 | 0.3 | 1 | 0.2 |
| 30 | ..... | ..... | ..... | ..... | 1 | 0.3 | 1 | 0.2 |
| Totals | 117 | 99.7 | 116 | 100.9 | 316 | 99.6 | 549 | 99.9 |

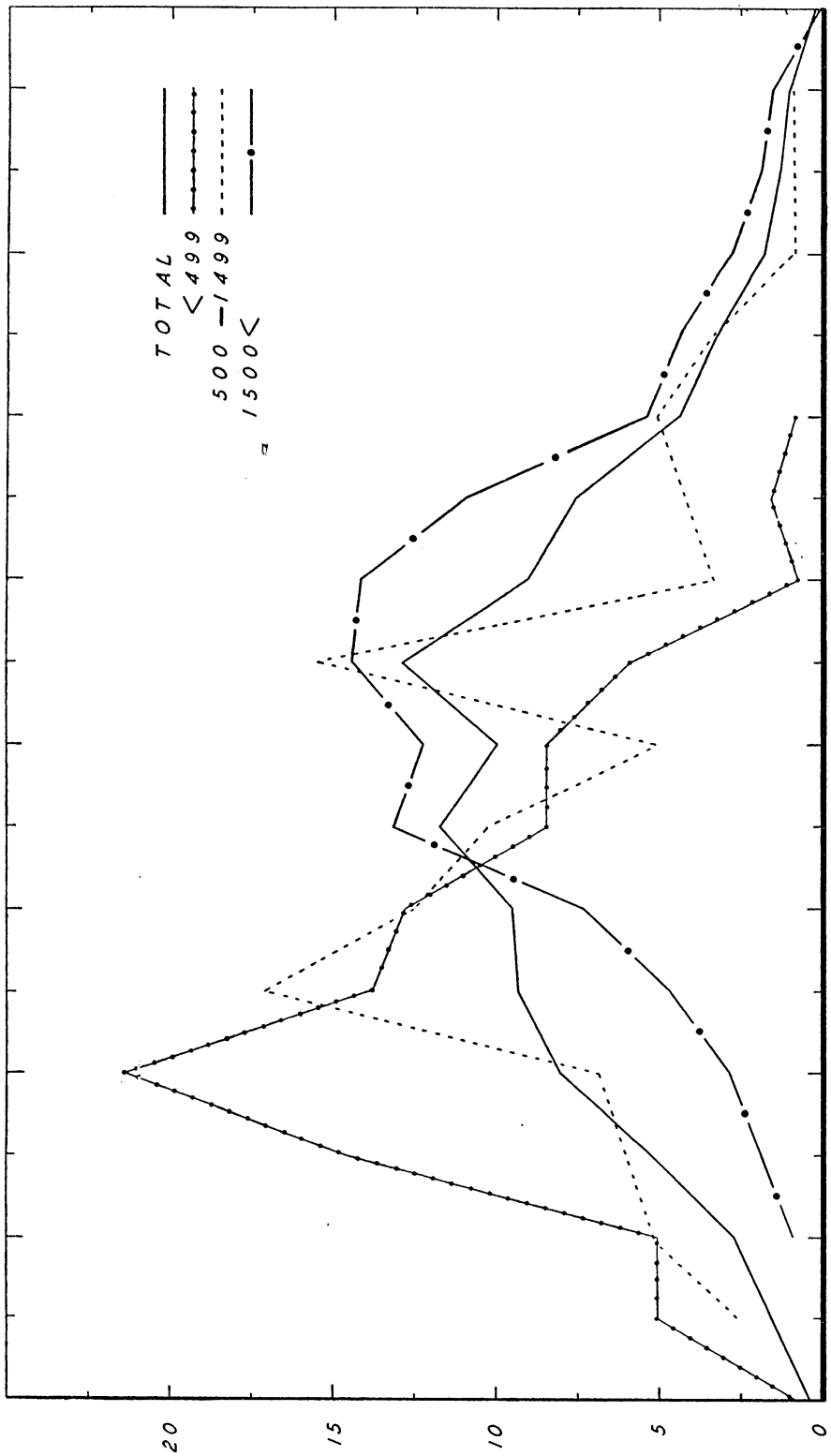



FIG. 3. Based on Table III. A decrease in size of specimens of *Obeliscus terebraster* is correlated with decreased land elevation. Points on the abscissa or base represent simple length measurements, and the peaks move from right to left.

According to Blauner (Shuttleworth, 1854: 141) *O. terebraster* is ovoviviparous. This observation is probably reliable, although it has not been verified with the material at hand. A number of specimens clearly show large eggs present in the uterus, but no completely formed shells were observed in the lower part of the genital tract. More detailed observations on the life history of this species would be of interest.

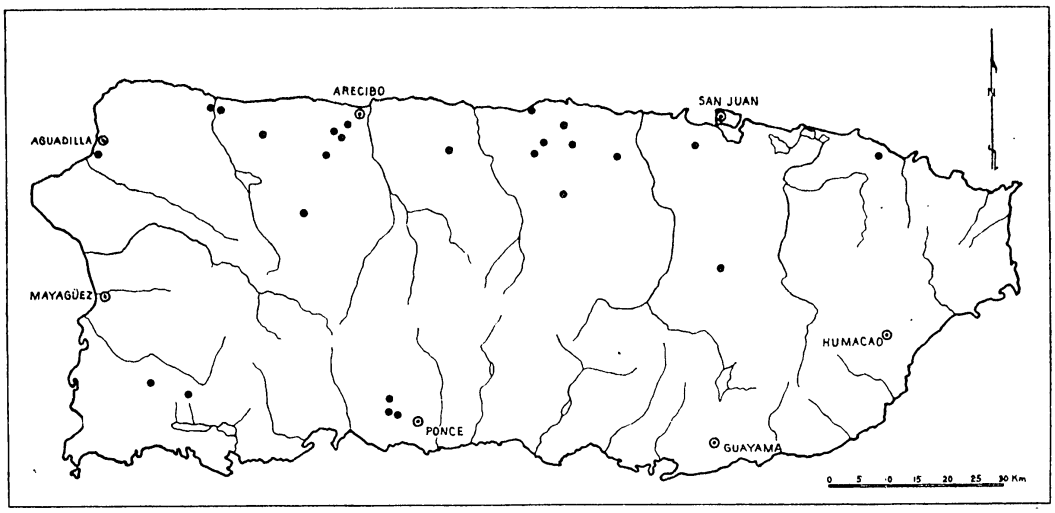
Table III and Figure 3 show that the lower altitudes (0–499 ft.) in Puerto Rico harbor the more stunted specimens (12–24 mm. in length). In the mountainous regions, roughly at altitudes of 1500 feet or more, large forms range from 13 to 30 mm. in length. The intermediate series, which are shown in Figure 3 by two modes, one at 17 mm. the other at 21 mm., indicate that certain lots in this group go with the upland forms, whereas others should probably be grouped with the lowland forms. The exact limits of the two series have not been established. Additional field work may clarify the status of these groups.

## *Obeliscus swiftianus* (Pfeiffer)

(Pl. IV, Fig. 10)

*Bulimus swiftianus* Pfeiffer, *Monographia Heliceorum viventium,* III (1853): 399.
*Stenogyra swiftiana* Pfeiffer, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 374.
*Obeliscus swiftianus* (Pfeiffer), Pilsbry, *Manual of Conchology,* 18 (1906): 268–69.

Unlike the other two species of *Obeliscus* (*dominicensis hasta* and *terebraster*), *swiftianus* is confined largely to the coastal plain of Puerto Rico and does not inhabit the Cordillera Central (Map 35). In fact, the largest series of *O. swiftianus* were taken on the coastal plain among dry limestone outcrops on both the north and south coasts; the same habitat usually yielded




MAP 35. Distribution of *Obeliscus swiftianus.*

few other species of *Obeliscus.* Blauner (Shuttleworh, 1854: 140) collected *swiftianus* at Luquillo, Fajardo, and Humacao, and its range will most likely extend completely around the island within the coastal plain. It is of interest to note that *O. swiftianus* is clearly a coastal plain form, just as are the two common Puerto Rico *Lamellaxis,* that is, *gracilis* and *micra,* and also *Opeas pumilum.*

## *Obeliscus dominicensis hasta* (Pfeiffer)

(Pl. V, Fig. 1)

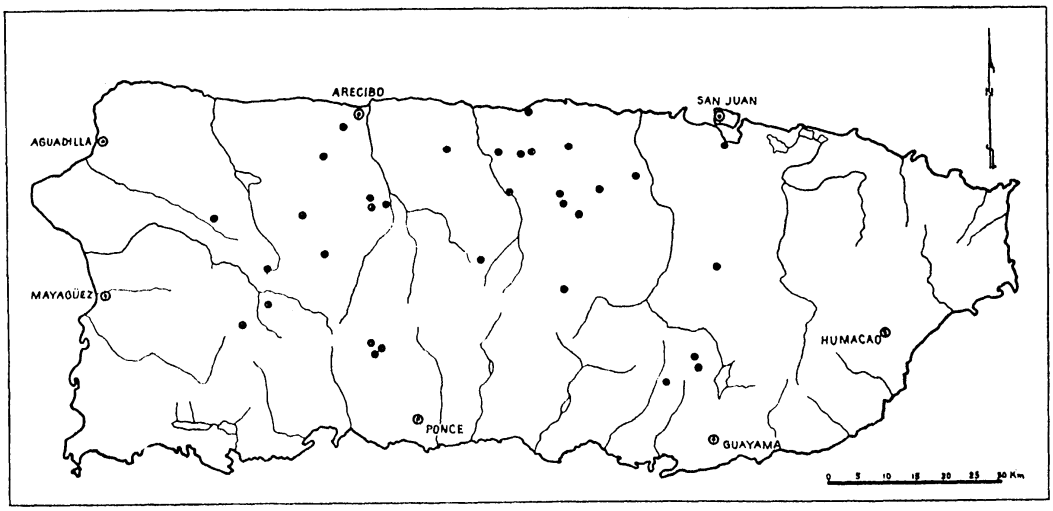
*Bulimus hasta* Pfeiffer, *Malak. Blätt.,* 3 (1856): 45.

*Pseudobalea dominicensis* Pfeiffer, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 375.

*Obeliscus dominicensis hasta* (Pfeiffer), Pilsbry, *Manual of Conchology,* 18 (1906): 272–74.

This species has a wide distribution throughout the island (Map 36). It was particularly common in moist regions, where it was usually most abundant among decaying leaves and rich vegetation covering large slabs of limestone. Although found among the limestone knolls of the north coastal plain, the best series were usually taken farther inland and in the higher, more mountainous parts of the island. The fact that no specimens were collected along the south coastal plain, which is known to be considerably drier than the northern plain, may indicate the preference of *O. dominicensis* for moisture. Blauner (Shuttleworth, 1854: 140) collected it at Luquillo. Even though it was rare there, *O. dominicensis* probably ranges considerably farther east than is shown (Map. 36). Gundlach, according to von Martens (1877: 349), collected it at Quebradillas, which extends the range somewhat farther west along the north coast.

There is at present some question as to whether the variety *hasta* is at all




MAP 36. Distribution of *Obeliscus dominicensis hasta.*

different from the typical form *O. dominicensis,* which inhabits Hispaniola. Pilsbry (1906: 273) stated: "Just what relation exists between *hasta* and *dominicensis* I am unable to state; but until differences are found to exist, the former may temporarily be ranked as a variety." Obviously, there is a definite need for comparative studies of Puerto Rican *O. dominicensis* with the forms inhabiting neighboring islands. H. B. Baker "found it mainly under disturbed conditions and very rarely in natural forest. It is suspected of being a species distributed by commerce, and that the '*hasta*' will be dropped some day."

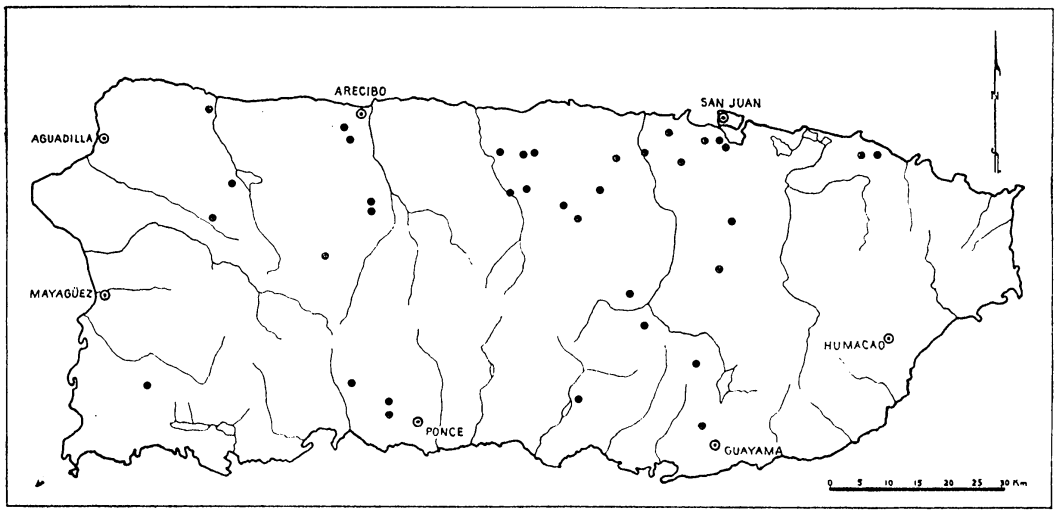
FAMILY OLEACINIDAE

## *Varicella portoricensis* (Pfeiffer)

(Pl. V, Fig. 8)

*Achatina portoricensis* Pfeiffer, *Proc. Zool. Soc.,* 1848, p. 111.
*Achatina riisei* Pfeiffer, *Zeitschr. f. Malak.,* 1852, p. 151.
*Varicella portoricensis* (Pfeiffer), Pilsbry, *Manual of Conchology,* 19 (1907): 122–23.
*Varicella* (*Vagavarix*) *portoricensis* (Pfeiffer), H. B. Baker, *Nautilus,* 55 (1941): 27, Pl. 2, Figs. 12–13.

This is one of the most common species of *Varicella* in Puerto Rico. It was observed to be abundant among the haystack knolls which are prominent along the northern coastal plain, east of San Juan. However, as the records (Map 37) show, *V. portoricensis* seems to go completely around the coastal




MAP 37. Distribution of *Varicella portoricensis.*

plain. It is scarce along the eastern and western part of that plain, and somewhat more common on the northern than on the southern plain. Records from Barranquitas, Aibonito, and the mountain mass south of Cayey, give evidence that it may occasionally appear in the mountainous parts of the island. Blauner collected *V. portoricensis* at Luquillo and Humacao

along the east coast, and Gundlach added Aguadilla to the localities not indicated on Map 37.

There is a rather wide range of variation in specimens of this species throughout the island. This is to be expected when one considers the striking environmental differences that exist between the various parts of the coastal plain inhabited by *V. portoricensis*. No definite trends have been observed or measured in the series collected, although it would be of some interest to see whether any measurable differences are noticeable among specimens in such widely diverse regions as exist between the wet northeastern part of the island and the dry southwestern zone.

## *Varicella calderoni* H. B. Baker

(Pl. V, Fig. 2)

*Varicella calderoni* H. B. Baker, *Notulae Nat.*, 88 (1941): 4–5, Fig. 5.
*Varicella (Vagavarix) calderoni* H. B. Baker, *Nautilus*, 55 (1941): 27–28.

During the summer of 1939 H. B. Baker (1941*c*: 5) discovered this species "under dead leaves, near summit of Yauco-Lares Road (PR6); elevation near 3000 feet." It was also found at Montoso (WR2) near Maricao at an elevation of 2000–2500 feet.

## *Varicella sporadica* H. B. Baker

(Pl. V, Fig. 3)

*Varicella sporadica* H. B. Baker, *Notulae Nat.*, 88 (1941): 5, Fig. 6.
*Varicella (Vagavarix) sporadica* H. B. Baker, *Nautilus*, 55 (1941): 28.

The type was taken by Baker (1941*c*: 5): "Under dead leaves, on ridge (ES4) about 1 mile south of Humacao." He also collected it at La Valera and near El Yunque. Three lots (Map 39) were taken in upland regions and consisted of but few specimens. The records thus far reported indicate that *V. sporadica* inhabits eastern and southeastern Puerto Rico.

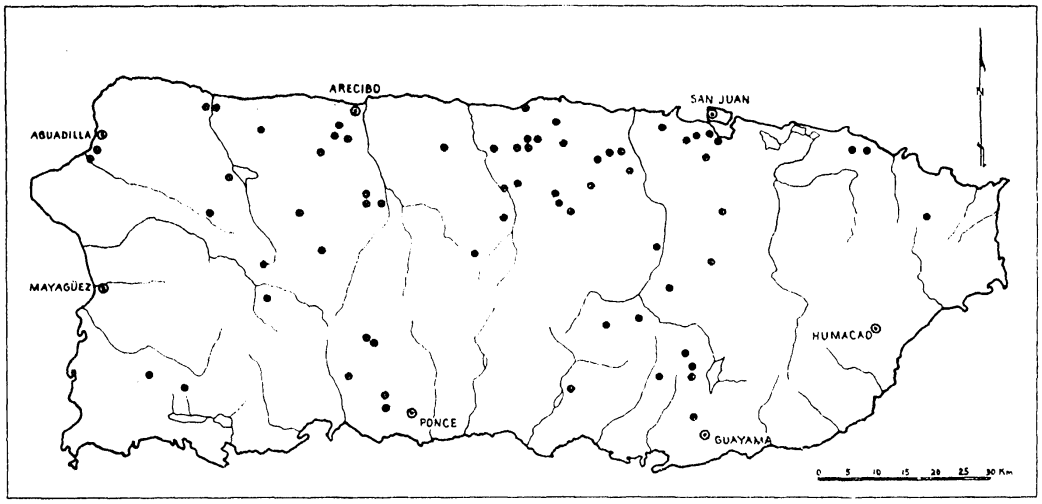
## *Varicella terebraeformis* (Shuttleworth)

(Pl. V, Fig. 4)

*Glandina terebraeformis* Shuttleworth, "Diagnosen . . . ," 1854, p. 144.
*Glandina sulculosa* Shuttleworth, "Diagnosen . . . ," 1854, p. 144.
*Glandina sulculosa* Shuttleworth, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 373.
*Glandina terebraeformis* Shuttleworth, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 373.
*Varicella sulculosa* (Shuttleworth), Pilsbry, *Manual of Conchology*, 19 (1907): 121–22.
*Varicella impressa* var. *terebraeformis* (Shuttleworth), Pilsbry, *Manual of Conchology*, 19 (1907): 119–21.
*Varicella (Vagavarix) sulculosa* (Shuttleworth), H. B. Baker, *Nautilus*, 55 (1941): 28, Pl. 2, Figs. 14–15.

Originally, Shuttleworth (1854: 144) described two species, *terebraeformis* and *sulculosa*. These were recognized as very similar, but were separated on the basis of shell sculpture. In his list, von Martens (1877: 345) recognized both species. Crosse (1892: 10) followed Shuttleworth in separating them as distinct. In a monographic treatment of *Varicella*, Pilsbry (1907: 119–22) stated: "From a study of the specimens before me from Haiti, Porto Rico and St. Thomas I am disposed to unite *G. terebraeformis* Shuttl. as a synonym or variety, though I have not seen types or topotypes of *V. impressa*." Because he had so little material, however, Pilsbry also recognized *V. sulculosa* in Puerto Rico. An examination of many specimens from this island has shown great variation in shape, size, and sculpture, and it seems from what evidence is available that *V. terebraeformis* and *V. sulculosa* are merely two names for one species. It appears that the former name has priority over the latter. The relationship between this species and related forms in Santo Domingo would make an interesting field for investigation.

*V. terebraeformis* and its forms range widely (Map 38) in Puerto Rico.




MAP 38. Distribution of *Varicella terebraeformis*.

Blauner collected it from Humacao. It is very abundant in the north-central part of the island among the haystack knolls of that region. Apparently, this species is not partial to the coastal plain limestone, but invades the forested region of the Cordillera Central, as well. There seems to be a stunting in forms at higher altitudes, where limestone outcrops are less common, but no careful measure of the amount of variation with altitude (perhaps moisture variation) has been measured or demonstrated. Opportunity for studies of this kind is afforded in a region such as one finds across the main mountain range when traveling the road from Cayey to Guayama.

H. B. Baker has made the following valuable observations with regard to the variation in these forms:

*V. sulculosa* (Sh.): ground, frequent, entire island except eastern mountains, 0–3000 ft.; impressed growth-striae exceedingly variable and size quite so; smallest (as small as *V. distans* Pilsbry) and most heavily sculptured in dry places with little cover (ES2) but divergent shells obtained within short distances on rocky hills; smoother form *terebraeformis* (Sh.) rarely with uniformly whitish shells (PN1, WR2, WS1).

## *Laevaricella interrupta* (Shuttleworth)

(Pl. V, Fig. 5)

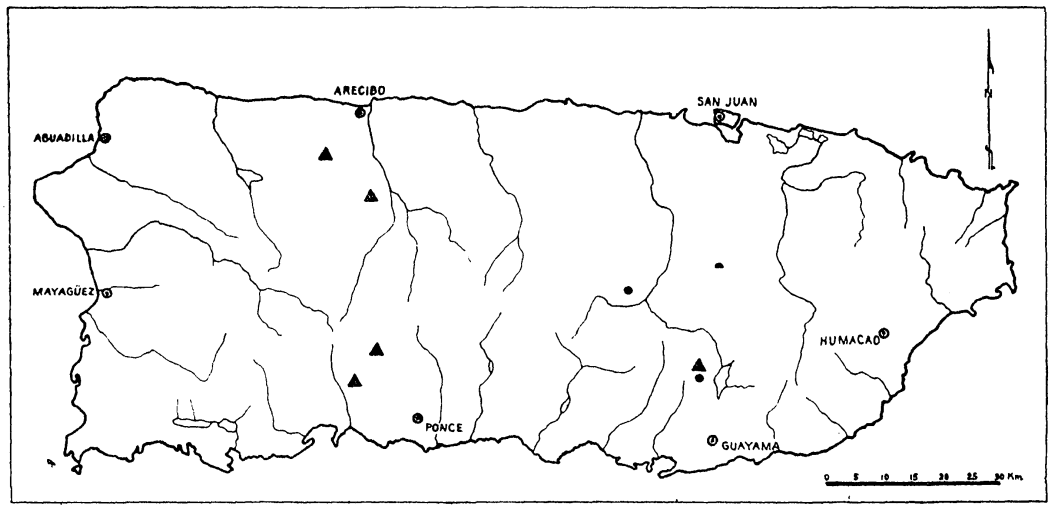
*Glandina interrupta* Shuttleworth, "Diagnosen . . . ," 1854, p. 143.

*Glandina interrupta* Shuttleworth, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 373.

*Varicella* (*Laevaricella*) *interrupta* (Shuttleworth), Pilsbry, *Manual of Conchology*, 19 (1907): 126.

*Laevaricella* (*s.s.*) *interrupta* (Shuttleworth), H. B. Baker, *Nautilus*, 55 (1941): 29, Pl. 2, Figs. 16–17.

This species seems to be intermediate between *L. glabra* and *V. portoricensis* in the size and shape of its shell and in the structure of the animal. Pilsbry (1907: 123) created a section *Laevaricella* for "*Varicellas* without




MAP 39. Distribution of *Varicella sporadica* (circles) and *Laevaricella interrupta* (triangles).

distinct grooves or striae between the varices. Embryonic shell pupiform (except in *V. glabra*) of 3 to 3½ smooth whorls: columella very concave and abruptly truncate." H. B. Baker (1941*b*: 29) raised the section name to generic status on the basis of anatomical differences and stated that "despite its geographic propinquity, the genus is very distinct from *Varicella*."

Shuttleworth based his description on material collected by Blauner, who found *L. interrupta* "rare under fallen leaves near Luquillo." E. von

Martens (1891: 131) reported that Sintenis collected it from El Yunque. As shown by the records more recently established (Map 39) this species appears to be most common in the mountainous regions of the central part of the island. This range is also given by H. B. Baker:

Arboreal (Cecropian), rare, El Yunque to Maricao, 2500–3500 ft.; at waterfalls at El Yunque; Sierra de Bandera, within 1 mile of highest point on Ponce to Adjuntas (and Jayuya) road (6640, 1809; over 3000; 20); collected Aug. 3 and Sept. 6. [Other stations are:] Top and west side of ridge south of highest point on road from Adjuntas to Guazas dam (6643, 1809; about 3000; 21); collected Sept. 7.; and heavier forest on ridge between CCC camps Buena Vista and Santana, west of Santa Ana peak (6659, 1809; around 3000; 32).

## *Laevaricella glabra* (Pfeiffer)

(Pl. V, Fig. 7)

*Achatina* (*Glandina*) *glabra* Pfeiffer, *Symbolae ad historiam Heliceorum*, III (1846): 90.

*Glandina glabra* Pfeiffer, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 374.

*Varicella* (*Laevaricella*) *glabra* (Pfeiffer), Pilsbry, *Manual of Conchology*, 19 (1907): 127.

*Laevaricella* (*Boriquena*) *glabra* (Pfeiffer), H. B. Baker, *Nautilus*, 55 (1941): 30, Pl. 1, Fig. 4.

As formerly conceived, *L. glabra* was the common, large, elongate, and smooth species common to Puerto Rico. Recently, H. B. Baker (1940*a*: 107) by way of an interpretation of the nomenclature has assigned the name *L. glabra* to a shorter, more rotund form which is restricted in its range to "the eastern mountains around El Yunque." This arrangement is being followed here. Baker has several records, and he has stated that *L. glabra* is a "very weak climber but mainly on fallen leaves, infrequent, eastern mountains, 2000–3000 ft. . . ."

## *Laevaricella playa* H. B. Baker

(Pl. V, Fig. 6)

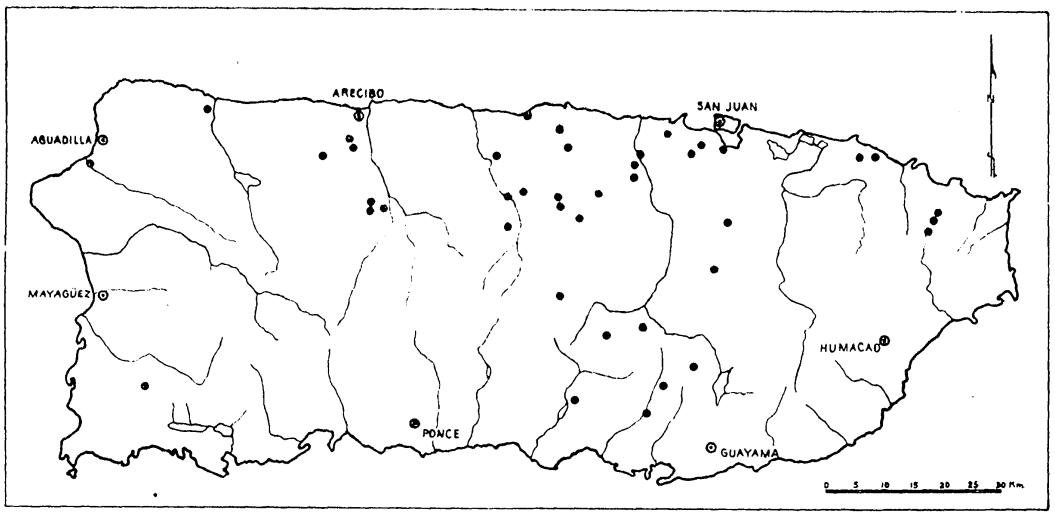
*Varicella glabra gracilior* Pilsbry, *Manual of Conchology*, 19 (1907): 127, Pl. 19, Fig. 37.

*Varicella* (*Laevericella*) *playa* H. B. Baker, *Nautilus*, 53 (1940): 107.

*Laevaricella* (*Boriquena*) *playa* H. B. Baker, *Nautilus*, 55 (1941): 29–30, Pl. 2, Figs. 18–20.

As previously mentioned, the common large *Laevaricella* in Puerto Rico is now recognized under the new name *L. playa*. Baker (1941*b*: 29–30) has studied this group anatomically and has found sufficient differences between the anatomy of this species and the preceding one to state: "Evidently, *L. playa* is almost sectionally distinct from *L. glabra*."

The pattern of distribution (Map 40) is interesting in that this species seems to inhabit a broad area across the northern coastal plain and foothills




MAP 40. Distribution of *Laevaricella playa.*

with an influx of these animals into the mountains of the eastern and south-central regions. Among a variety of species taken south of San German in the southwestern part of the island, there is but a single specimen of *L. playa.*

FAMILY HAPLOTREMATIDAE

## *Austroselenites concolor* (Férussac)

(Pl. V, Figs. 9*a*, *b*, *c*)

*Helix concolor* Férussac, *Histoire naturelle des mollusques terrestres,* 1821, p. 208, Pl. 82, Fig. 2.

*Circinaria concolor* Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 374.

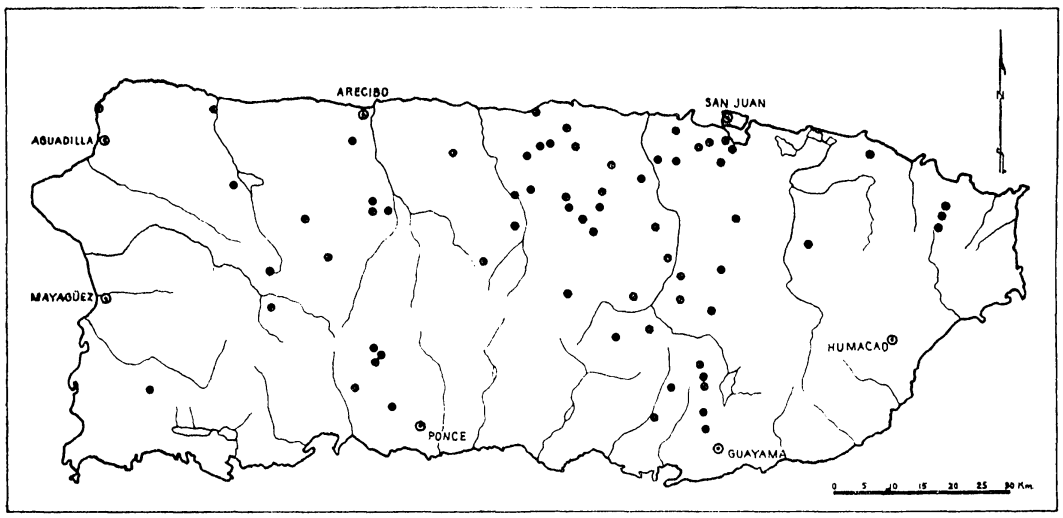
*Haplotrema (Zophos) concolor* (Férussac), H. B. Baker, *Proc. Acad. Nat. Sci. Phila.,* 82 (1930): 422, Pl. 35, Figs. 7–9.

*Austroselenites (Zophos) concolor* (Férussac) H. B. Baker, *Nautilus,* 54 (1941): 132–34, Pl. 9, Figs. 6, 7.

*A. concolor* was found to be common by Blauner around Humacao, Luquillo, and San Juan. He was apparently the first to observe that it was ovoviviparous, and he also asserted that it did not produce more than four young. H. B. Baker (1941*a:* 133) reported that "the uterus in some specimens contained as many as 7 large, shell-less eggs, in others embryos." A specimen collected four kilometers south of La Muda, November 24, 1940, had two young, well-formed shells in its uterus.

The genus name applied to *A. concolor* has been changed several times: Shuttleworth applied *Helix,* E. von Martens used *Morchia* or *Moerchia,* Tryon (1886: 208) employed *Selenites,* Dall and Simpson (1901: 374) adopted *Circinaria.* It has also been placed in *Zophos* and *Macrocyclis.* H. B. Baker included it in *Haplotrema* and more recently in *Austroselenites.*

In the seventy lots of *A. concolor* (Map 41) collected in various parts of




MAP 41. Distribution of *Austroselenites concolor*.

the island considerable variation was observed in the size and color of the individuals. While it is true generally that young individuals are black and older ones brown, in some groups young specimens are brown. Since most of the collections available to me are in small series a statistical analysis is not likely to give reliable results. A study designed to correlate the variations observed in this species with conditions in its environment might well prove interesting.

## *Austroselenites alticola* H. B. Baker

(Pl. V, Figs. 10*a*, *b*)

*Austroselenites* (*Zophos*) *alticola* H. B. Baker, *Nautilus*, 54 (1941): 135–36, Pl. 9, Fig. 8–12.

As compared to the previous species, this one is relatively uncommon. It appears to be restricted to the high mountainous region of the island from El Yunque to Maricao. The differences between *A. alticola* and *A. concolor* have been defined by Baker as follows:

> The difference is in the relatively smaller sutural spiral, bulkier whorls and relatively smaller umbilicus of *A. alticola, when shells of the same diameter are compared.* Without examination of the animal, young (small) specimens of the two species are very difficult, but the *large* shells of *A. alticola* are very different from the *large* ones of *A. concolor.* Of course, the principal difference is in the radula. *A. alticola* has radular teeth such as have been described in no other pulmonate, outside the Testacellidae, to the best of my knowledge and belief.

FAMILY STREPTAXIDAE

## *Gulella bicolor* (Hutton)

(Pl. V, Figs. 11*a*, *b*)

*Pupa bicolor* Hutton, *Journ. Asiatic Soc. Bengal*, III: 86.

*Ennea bicolor* Hutton, Tryon, *Manual of Conchology*, 2d ser., 1 (1885): 104, Pl. 19, Figs. 14, 17, 18; Pl. 20, Fig. 24.
*Gulella bicolor* (Hutton), Pilsbry, *Proc. Acad. Nat. Sci. Phila.*, 78 (1926): 98.

Only a single specimen was collected in a small park in the heart of the city of Guayama. It is another introduced species. H. A. Pilsbry (1926*a:* 98) reported it from Taboga Island, Panama City, and Ancon, and stated: "This small, toothed oriental-region snail is very unlike any American species. Originally described from India, it is now widely spread in the tropics. It is common around Havana and was taken last year at Manaos, Brazil." In a recent letter, J. C. Bequaert kindly gave the following information:

With regard to *Gulella bicolor* Hutton, this should, I believe, be placed in a distinct genus *Diaphora* (originally spelled *Diaphera* by Albers). It is strictly Oriental (with many species), whereas true *Gulella* is African. The occurrence of *D. bicolor* outside the Oriental region is entirely due to transport by man. Our American lots of *D. bicolor* are from Brazil (Manaos), French Guiana (Cayenne), Trinidad (St. Augustine; Galeota Point), St. Thomas, St. Croix (Rustop-Twist; Concordia; Bethlehem), Santo Domingo (Puerto Sosua), Cuba (Cardenas; El Purio; Calabazar de Sagua; Havana), Isle of Pines, and South Carolina (Charleston).

Recently, C. G. Aguayo (1944: 56) gave additional information regarding its presence in Cuba.

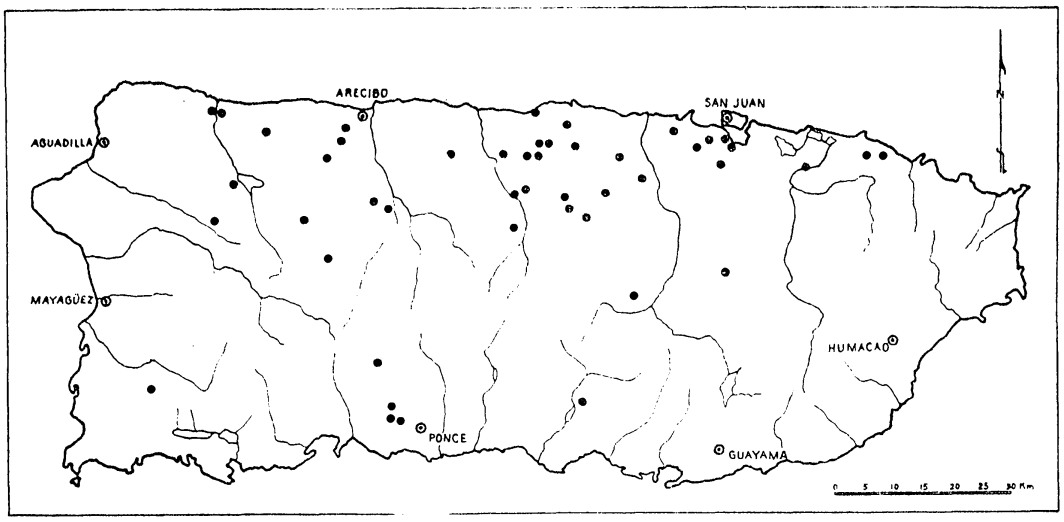
## FAMILY POLYGYRIDAE

### *Thysanophora plagioptycha* Shuttleworth
(Pl. V, Fig. 12)

*Helix plagioptycha* Shuttleworth, "Diagnosen . . . ," 1854, p. 129.
*Zonites plagioptycha* Shuttleworth, Tryon, *Manual of Conchology*, 2d ser., 2 (1886): 174, Pl. 53, Fig. 51.
*Thysanophora plagioptycha* Shuttleworth, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 379.

Shuttleworth described *T. plagioptycha* from material collected by Blauner in eastern Puerto Rico. It is a very common shell and seems most prevalent among the limestone outcrops of the coastal plain (Map 42). Very few records have been established for the high mountain region of the island. In addition to the stations given, Blauner has added Fajardo, Ceiba, Rio Blanca, and Humacao, giving "under decayed wood and below stones" as its habitat. This species, like *Pupisoma dioscoricola,* with which it usually occurs, is widespread in distribution. It has also been reported from Florida. Pilsbry (1920: 95) noted that *T. plagioptycha* was established in Venezuela and Colombia. Both Hinkley and van der Schalie have taken it in Guatemala. In a review of the genus *Thysanophora* Pilsbry (1926*a:* 115) briefly summarized the distribution of this species as follows: "Florida and West Indies to Venezuela; Mexico."

H. B. Baker kindly gave the following information:




MAP 42. Distribution of *Thysanophora plagioptycha.*

When active, this species is largely leaf-arboreal, although it aestivates on the ground. It was not collected in semideserts or richer forests. I suspect that the drouth had reduced the numbers of this species, but its absence from the richer forests where repeated searches were made for it agrees with the hypothesis that *Lyroconus* like *Thysanophora* s.s. is native to the mainland, and has been introduced into the Antilles.

## *Mcleania darlingtoni* Bequaert and Clench

(Pl. VI, Fig. 1)

*Moleania darlingtoni* Bequaert and Clench, *Mem. soc. cubana hist. nat.*, 13 (1939): 283–84, Pl. 36, Figs. 4–6.

*Mcleania darlingtoni* Bequaert and Clench, H. B. Baker, *Nautilus*, 54 (1940): 55–57, Pl. 4, Figs. 1–4.

In 1938, during an expedition for the purpose of collecting insects, P. J. Darlington, of the Museum of Comparative Zoology, found this striking endemic species buried "several inches deep in a pile of decayed wood chips." The collection was made in the Maricao forest of western Puerto Rico, at an elevation of 2500 feet. Bequaert and Clench (1939) described this highly characteristic shell as a new genus. H. B. Baker (1940*c:* 55–57) visited the Maricao region, where he managed to get specimens for dissection. Baker's specimens were collected "from cloud zone forest, under decaying wood, in Maricao Forest, on main ridge south of Maricao; also found under dead palm leaves, on ridge west of Adjuntas." Baker's dissections revealed that, although its radular characters also emphasized that it should be retained as a genus: "*Mcleania* seems fairly close to typical *Thysanophora,* or, at least, to the only section (*Microconus*) of which the anatomy is known."

## *Microconus* cf. *wilhelmi* (Pfeiffer)

(Pl. VI, Figs. 4*a*, *b*)

*Helix wilhelmi* Pfeiffer, *Malak. Blätt.*, 13 (1886): 79.

*Helix (Patula) wilhelmi* Pfeiffer, Fischer and Crosse, *Mission scientifique au Mexique, Mollusca*, 1 (1870): 230, Pl. 10, Figs. 5, 5a, 5b.

*Microconus wilhelmi* (Pfeiffer), H. Strebel and G. Pfeffer, *Beitrag . . . mex. Land-u. Süsswasser Conch.*, IV (1880): 29, Pl. 4, Fig. 7.

This small species is placed here with some doubt. A comparison of the Puerto Rican material with specimens of *Microconus wilhelmi* in the University of Michigan collections shows considerable resemblance. Also, the original description of *M. wilhelmi* rather closely fits the characters of the Puerto Rican specimens. As for the relative position of this genus, a statement made by Pilsbry (1926*a:* 81) appears appropriate at this time:

> *Microconus* Strebel and Pfeffer, based upon the single species *Helix wilhelmi* Pfr., is one of several East Mexican groups of small helicoids which cannot yet be classified definitely. The shell has some resemblance to the Palaearctic genus *Pyramidula* (*P. rupestris*), belonging to or near the Pupillidae. It might, again, prove to be an endodontid snail, or it may belong in or near *Thysanophora*. Until something is known of the anatomy, I do not see that there is sufficient evidence for forming an opinion, and none is intended by the place here given it.

As indicated in the discussion under the previous species, H. B. Baker has recently contributed information relating to the anatomy of *Microconus*.

Three small lots of this *Microconus* were taken at the following localities: on a limestone knoll about nineteen kilometers northwest of Ponce; near caves about three kilometers southwest of Aguas Buenas; and along bank of Rio Mabille, north of Corozal.

## FAMILY SAGDIDAE

### *Yunquea denselirata* H. B. Baker

(Pl. VI, Fig. 5)

*Yunquea denselirata* H. B. Baker, *Nautilus*, 54 (1940): 57–58, Pl. 4, Figs. 5–9.

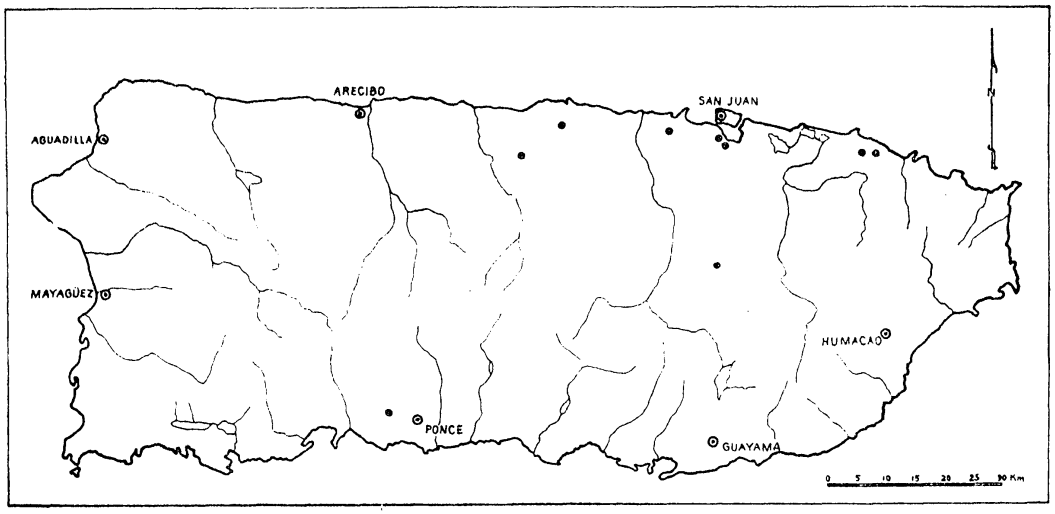
This small and rare Puerto Rican shell was only recently discovered and described by H. B. Baker (1940*a:* 57–58). He has shown that *Yunquea*, although related to *Aquebana*, is generically distinct; the distinctions are based largely on radular and genital differences. As implied by the specific name, there is a characteristic sculpture on the shell which is described by Baker but not figured. As an aid in identifying the shell, the characteristic sculpture is shown in the figure given for this species. The single specimen taken in my series emphasizes not only the need for carefully searching for the rare *Yunquea* in Puerto Rico, but also that this unique species is not confined to the El Yunque region of the Luquillo mountain range. The specimen figured in this report was taken at an altitude of not more than 200 feet in the densely wooded region surrounding the caves about three kilometers south of Aguas Buenas.

## *Aquebana velutina* (Lamarck)

(Pl. VIII, Fig. 1)

*Helix velutina* Lamarck, *Histoire des animaux sans vertèbres . . .*, VI, Pt. 2 (1882): 86.
*Helix velutina* Lamarck, Tryon, *Manual of Conchology*, 2d ser., 3 (1887): 100, Pl. 22, Figs. 30–32.
*Thysanophora velutina* Lamarck, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 380.
*Aquebana velutina* (Lamarck), H. B. Baker, *Nautilus*, 54 (1940): 59–60, Pl. 5, Figs. 15–17.

Pilsbry (1926*a*: 111) first proposed *Aquebana* as a subgenus under *Suavitas* and suggested that the type would be "*Helix velutina* Lam. of Pfeiffer, Porto Rico." Recently, H. B. Baker (1940*c*: 59) raised *Aquebana* to generic rank. According to Baker's account (1940*c*: 58) *A. velutina* is most common along the northeastern shore (Map 43) of the island, but future




MAP 43. Distribution of *Aquebana velutina*.

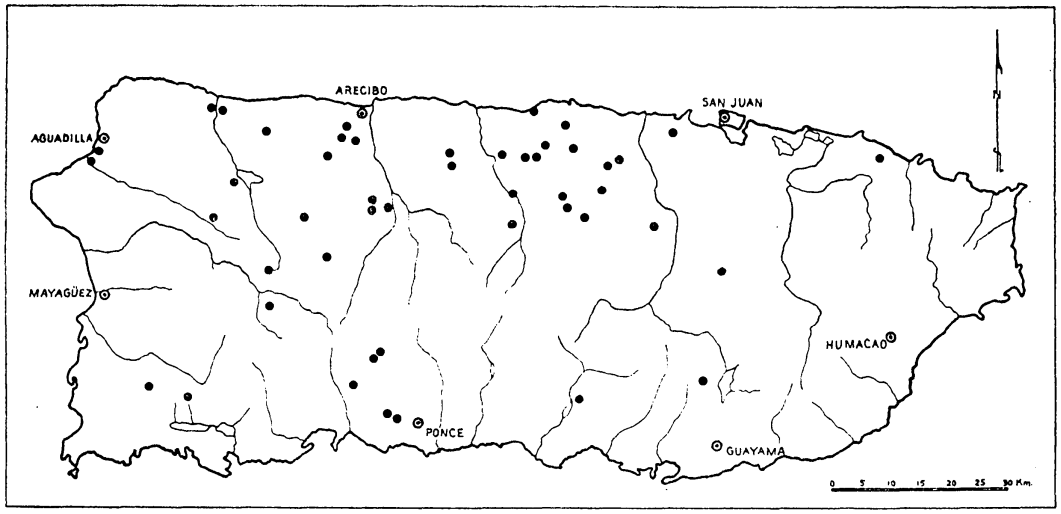
studies may add data for parts of the southern coastal plain which may not have been sufficiently explored. Baker has found that "this is a burrowing species, like *Megalomastoma croceum* in the same habitat. Living animals rare, deep in rocks; dead shells were frequent. Snail rarity probably due to drouth."

## *Hyalosagda subaquila* (Shuttleworth)

(Pl. VIII, Fig. 2)

*Helix subaquila* Shuttleworth, "Diagnosen . . . ,", 1854, p. 37.
*Helix subaquila* Tryon, *Manual of Conchology*, 2d ser., 3 (1887): 98, Pl. 19, Fig. 31.
*Thysanophora subaquila* Shuttleworth, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 379.
*Hyalosagda* (*Microsagda*) *subaquila* Shuttleworth, H. B. Baker, *Nautilus*, 54 (1940): 60, Pl. 5, Fig. 3.

This is one of the most common species in Puerto Rico. It is especially prevalent along the north and south coastal plain (Map 44). Usually,




MAP 44. Distribution of *Hyalosagda subaquila.*

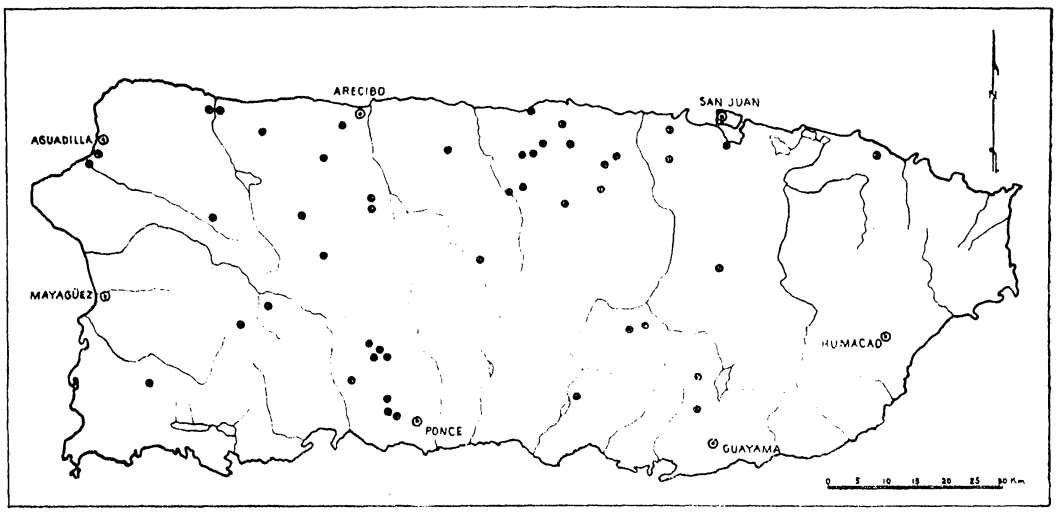
*Lacteoluna selenina* is associated with it. In the mountainous interior, however, particularly east of Jayuya, *H. subaquila* is seldom present. In general, it inhabits regions having dry limestone outcrops, where it may occur in great numbers. Until recently, the generic position of *H. subaquila* was uncertain, but H. B. Baker (1940*c:* 60) dissected specimens taken from the canyon of Rio Grande de Arecibo and established it as belonging to *Lacteoluna* which he considered a subgenus of *Hyalosagda,* but which Pilsbry (1926*a* and 1940) regarded as a distinct genus. Blauner (Shuttleworth, 1854: 129) found it abundant along the eastern coast at Luquillo, Fajardo, Ceiba, and Humacao.

## *Lacteoluna selenina* (Gould)

(Pl. VI, Figs. 3*a*, *b*)

*Helix vortex* Pfeiffer, *Archiv f. Naturg.*, 1 (1839): 351, *non* Linnaeus.
*Helix selenina* Gould, *Proc. Boston Soc. Nat. Hist.*, 3 (1848): 38.
*Helix vortex* Tryon, *Manual of Conchology*, 2d ser., 3 (1887): 98, Pl. 19, Figs. 25–28.
*Thysanophora vortex* Pfeiffer, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 379.
*Lacteoluna selenina* (Gould), Pilsbry, *Proc. Acad. Nat. Sci. Phila.*, 78 (1926): 108–9.
*Lacteoluna selenina* (Gould), Clench, *Mem. soc. cubana hist. nat.*, 12 (1938): 323.

To some, this species will be more familiar under the name *Thysanophora vortex* (Pfeiffer). The change was made by Pilsbry (1926*a:* 1940), who showed that *Helix vortex* Pfeiffer is a homonym of *H. vortex* Linnaeus, so that Gould's *H. selenina* should, therefore, be substituted. In Puerto Rico *L. selenina* is one of the most common and widespread species (Map 45).




MAP 45. Distribution of *Lacteoluna selenina.*

Like *L. subaquila,* it is abundant among the massive limestone outcrops along the coastal plain. Sizeable colonies, however, were also observed in the more densely wooded regions of the main mountain mass. One of the largest colonies taken was on the trunks of banana trees in the Cordillera Central south of Cayey. Fresh specimens often have a coating of mud adhering to their shells arranged so as to give the shell a serrated edge. Few records are available for the eastern part of the island, but Blauner (Shuttleworth, 1854: 128) collected it at Ceiba and Luquillo.

## *Lacteoluna krugiana* von Martens

*Helix* (*Microphysa*) *krugiana* E. von Martens, *Jahrb. d. deutschen malak. Gesellsch.,* 4 (1877): 346, Pl. 12, Fig. 4.

*Thysanophora krugiana* von Martens, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 379.

## *Platysuccinea portoricensis* (Shuttleworth)

(Pl. VI, Fig. 2)

*Simpulopsis portoricensis* Shuttleworth, "Diagnosen . . . ," 1854, p. 147.

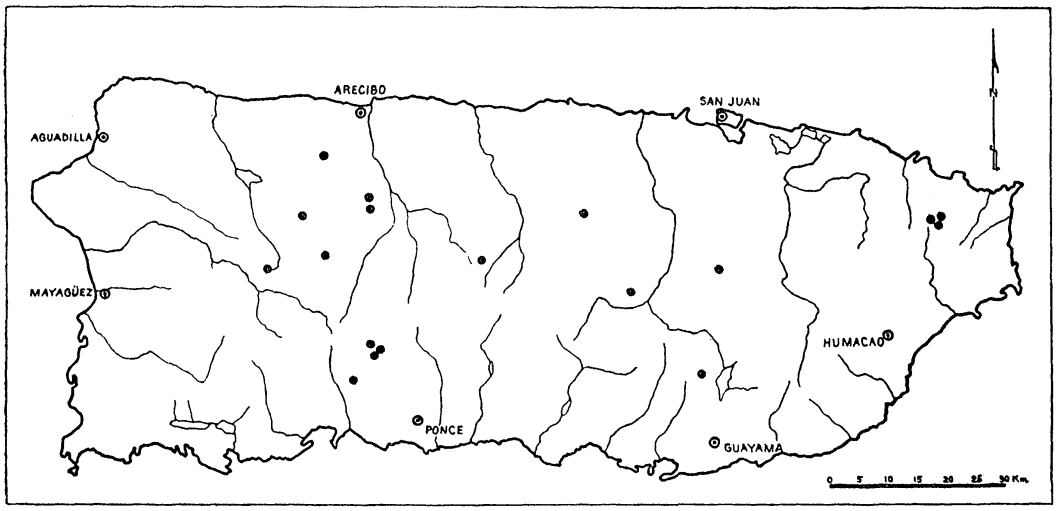
*Simpulopsis portoricensis* Shuttleworth, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 377.

*Platysuccinea portoricensis* Shuttleworth, Pilsbry, *Manual of Conchology,* 2d ser., 12 (1899): 224.

*Platysuccinea portoricensis* (Shuttleworth), H. B. Baker, *Nautilus,* 54 (1940): 61–62, Pl. 5, Figs. 18–20.

Until recently, this species was placed under *Simpulopsis.* H. B. Baker (1940*c:* 61–62) studied the anatomy of *P. portoricensis* and reported that it is "an aberrant sagdid and is not related to *Simpulopsis.*" Ecologically, he (1940*c*) found that "it occurs rarely, deep under rocks, on the lowlands,

but is common, on fallen leaves, in the more humid mountains, especially under ruderal conditions.'' Shuttleworth (1854: 147), reporting on the collections made by Blauner, reported it as common on banana leaves in the Luquillo Mountains. The tendency for *P. portoricensis* to appear in the higher and wetter uplands is clearly shown by the distribution records (Map 46). It was not common on the coastal plain, and where it was taken




MAP 46. Distribution of *Platysuccinea portoricensis.*

in the lowlands the colonies were represented by far fewer specimens than those which were in the high forested regions. Baker stated:

> In the lowlands, *P. portoricensis* lives deep in rock talus and so is easily missed. Like *Zonitoides arboreus,* it seems to flourish in acid (rotten) places. I also should have said 'It was found locally.' In one place near sea level (Old Loiza), where I was digging out quite a large area to get living animals of *Aquebana velutina,* it was fairly frequent, 1–3 feet below the surface.

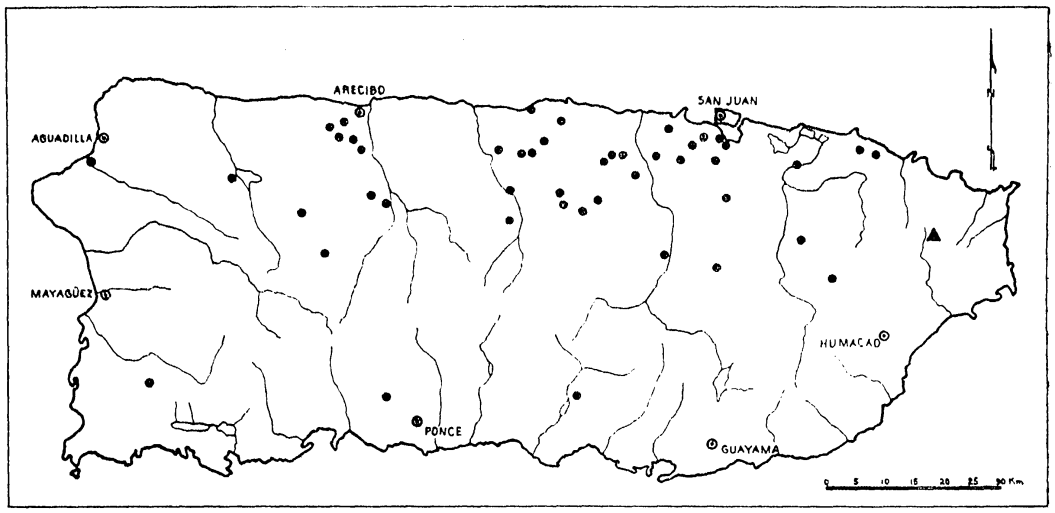
FAMILY CAMAENIDAE

## *Pleurodonte marginella* (Gmelin)

(Pl. VI, Fig. 6)

*Helix marginella* Gmelin, Shuttleworth, ''Diagnosen . . . ,'' 1854, p. 134.
*Helix* (*Carocolla*) *marginella* Gmelin, von Martens, *Jahrb. d. deutschen malak. Gesellsch.,* 4 (1877): 348.

This species has been called *P. bornii,* but more recently there seems to be some agreement that the specimens in Puerto Rico should be considered as listed above. Puerto Rican specimens are particularly common (Map 47) along the entire coastal plain and foothill sections of the northern half of the island. A few records have been established along the southern coastal plain, but *P. marginella* has not been taken in the higher mountainous interior of the island. The largest colonies are generally on the bark of the




MAP 47. Distribution of *Pleurodonte marginella* (circles) and *Polydontes luquillensis* (triangles).

trunk and lower branches of trees. The "flamboyant" tree (*Poinciana regia*), which has been planted along the principal highways throughout the island, harbors many flourishing colonies of this snail.

Both Thomas Bland (1875: 80) and von Martens (1877: 349) reported specimens of *P. marginella* devoid of the characteristic dark color band of this species. The former observed this in a specimen from the region of San Juan, and the latter reported that the "white" specimen he saw came from the province of Mayaguez. In my collections there is an albino from a haystack knoll about five kilometers southeast of Vega Baja. H. B. Baker stated: "Have shells from living animals which are as close to white (albino) as the shell can get; actually sort of pale greenish." Apparently, the bandless form appears among colonies in an independent way and can be considered as of relatively rare occurrence.

Additional records extending the range southeastward and southwestward are given by H. B. Baker as follows: Point Barrancas near Fajardo, a few colonies near Humacao, near Guanica Harbor on the south shore (dead shells only), a form "with broader dark band" at the southeast side of Montoso (west of Mayaguez), south of the town of Cabo Rojo, and at Mayaguez. According to these records and those of von Martens for Las Marias *P. marginella* is distributed almost completely around the island along the coastal plain, leaving only the region on the plain between Coamo and Humacao to be examined for the presence of this species.

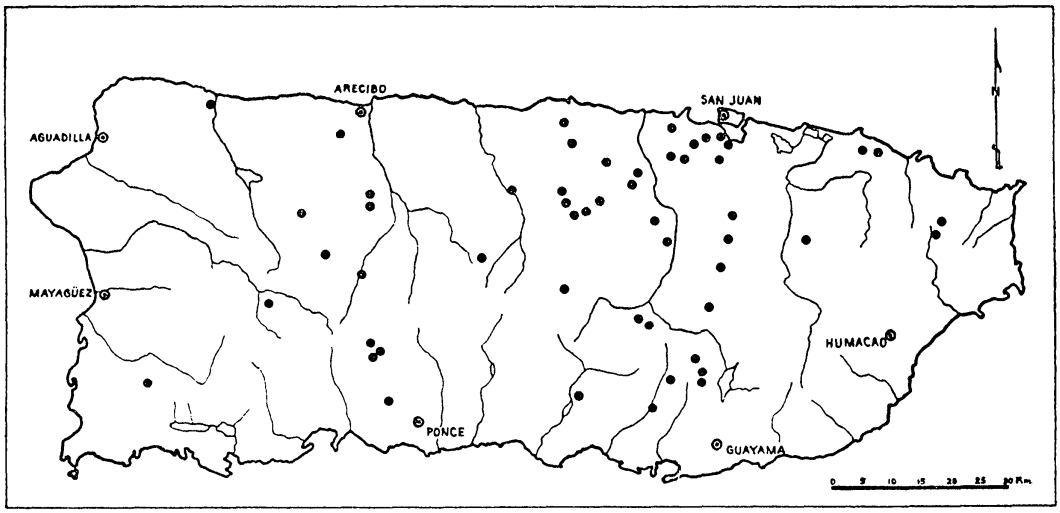
## *Pleurodonte carocolla* (Linnaeus)

(Pl. VI, Fig. 7)

*Helix carocolla* Linnaeus, *Systema naturae*, ed. 10, 1758, p. 769; Martini and Chemnitz, *Systematisches Conchylien Cabinet*, 9: 95, Pl. 125, Figs. 1090–91.

*Pleurodonte carocolla* Linnaeus, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 380.

This is one of the largest land shells in Puerto Rico, although *Polydontes acutangula* represents far the larger animal. It is widely scattered throughout the island (Map 48). In addition to the records established, H. B.




MAP 48. Distribution of *Pleurodonte carocolla.*

Baker has recently collected *P. carocolla* from the region southeast of Humacao. My records are sparse along the west coast, but Gundlach (von Martens, 1877: 348) collected *P. carocolla* at Aguadilla and Las Marias. It was most common in trees of the wet tropical forest at El Yunque, where it was the most abundant member among species of this genus. Along the dry, haystack knolls of the northern coast, *P. carocolla* was usually buried or moving (in wet weather) among the decayed leaves and stones on the slopes.

Some 313 specimens from various parts of the island were measured in an effort to establish whether *P. carocolla* varied consistently in certain zones of its range. There was a rather wide variation in size; diameters varied from 42 mm. to 59 mm. with the bulk of the specimens grouped between 44 and 55 mm. There was practically no consistent stunting correlated with altitude; a series of specimens from the coastal plain near Loiza was about the same in size as a similar series from a higher, wetter habitat at El Yunque.

## *Polydontes lima* (Férussac)

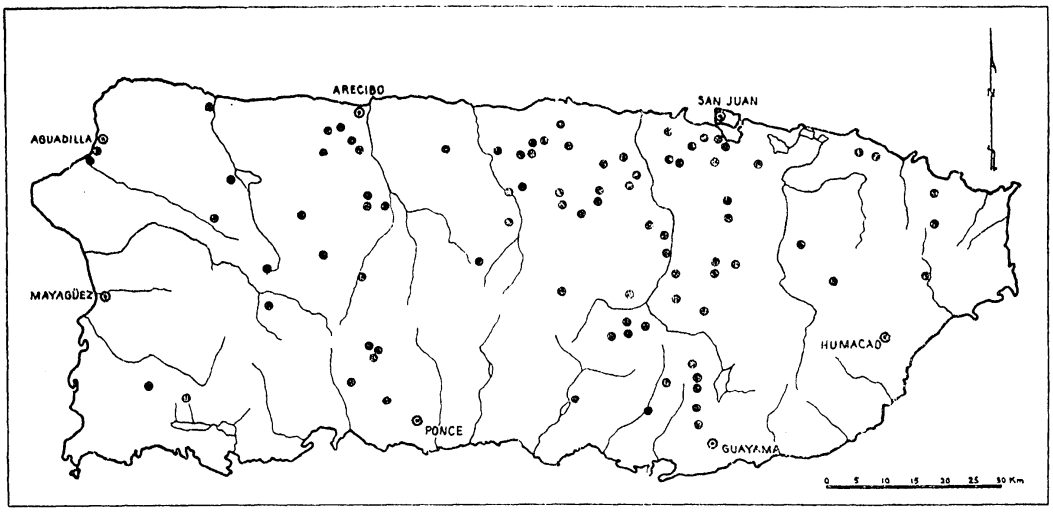
(Pl. VI, Fig. 8)

*Helix* (*Helicogena*) *lima* Férussac, *Tableaux . . . mollusques . . . Prodrome,* 1821, p. 81; Pl. 46, Figs. 1, 2.

*Pleurodonte lima* Férussac, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 381.

*Polydontes lima* Férussac, Clench, *Mem. soc. cubana hist. nat.,* 14 (1940): 243, Pl. 42, Fig. 6.

Of the larger forms in Puerto Rico, *P. lima* is one of the most abundant and widespread (Map 49). The animals are usually on the trunks and branches of trees, where large series often live close together. Although this species is more common at the lower elevations throughout the island, it is, nevertheless, well represented at higher altitudes in the interior mountain mass. In more elevated areas, the specimens are usually small, and with a smaller size there is a corresponding reduction in their granular sculpture. As a result, the roughly sculptured and larger individuals of the coastal plain become the stunted and finely granular specimens of the higher mountainous regions. In order to make this transition graphic




MAP 49. Distribution of *Polydontes lima*.

Table IV and Figure 4 portray the measurements of 1280 specimens. The localities have been grouped roughly into four major categories according to approximate elevations. Table IV and Figure 4 illustrate the trend toward stunting in the mountainous interior. For example, if one compares the peaks in the curves for specimens taken at the lowest elevations, 0 to 49 feet, it will be seen that the bulk of the population has a maximum diameter of 26 mm. The corresponding measurement for specimens taken at the highest altitudes, 1500 feet or over, is nearer 23 mm. Successive series measured fall at points intermediate, indicating that the transition is gradual from lower to higher elevations. The mean curve (Fig. 4) for all of the groups is the usual bell curve of normal distribution. In this connection, it should be emphasized that the small, stunted individuals are not restricted to the higher parts of the island. Figure 4 and Table IV show that small finely granular specimens are also in colonies that have the large and coarsely reticulate specimens. It should be noted, however, that the large and coarsely sculptured specimens are uncommon at high elevations.

These measurable differences in size and sculpture of *P. lima* have given

rise to considerable confusion in the taxonomy of this variable group. The smaller, somewhat stunted and finely granular or reticulate forms have the name *castrensis,* which is considered by Pilsbry (1889: 59) as a variety of *P. lima;* Crosse (1892: 17), followed by Dall and Simpson (1901: 381), gave specific rank to *P. castrensis.*

In this connection, it was of some interest to find that in a lot of 113 specimens from Juncos there were thirty-seven specimens that were com-

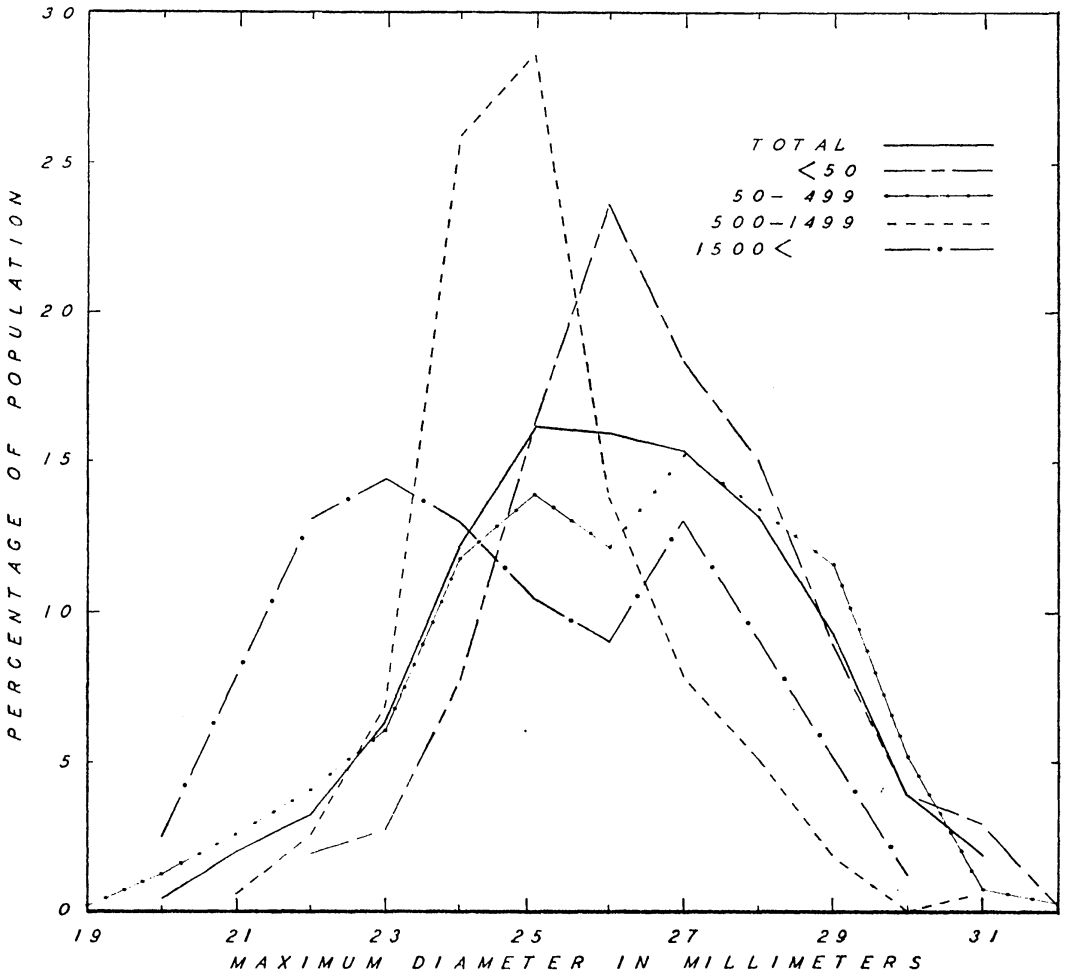



FIG. 4. Based on Table IV. A decrease in size of specimens of *Polydontes lima* is correlated with increased land elevation. Figures along the abscissa or base are a direct maximum diameter measurement and the peaks move from left to right.

pletely devoid of granular sculpture, whereas the remaining seventy-six had the sculpture well developed. Such a proportion in a random sample suggests that the presence of sculpture may well be determined as an hereditary factor which behaves according to a Mendelian ratio. The relative significance of the presence or absence of sculpture is certainly not well established, but this instance suggests that breeding experiments with forms

of this type could give valuable information as to the relative value of this character in the taxonomy of the *P. lima* group.

Two other names which have been applied to species closely related to *P. lima* are *P. incerta* (Férussac) and *P. maricao* Clench. The former is, according to Pilsbry (1889: 58), more common to the Virgin Islands. Just what the relations of *incerta* and *lima* are is difficult to determine. The several diagnostic characters given to differentiate *incerta* from *lima* hardly seem significant enough to warrant a distinct species. Yet, a comparative study of series from the Virgin Islands with series of specimens of *lima* from Puerto Rico may prove a fruitful endeavor. H. B. Baker (1924: 108) stated: "Finally, if Férussac's variety (not *P. lima*) requires a name it must be called *Pleurodonte incerta asperula* (Beck). This form is now known to occur in Porto Rico." The latter, *P. maricao,* represents the stunted, finely granular form of *P. lima* from the high elevations in Puerto Rico. There is a gradual series of forms that bridges the gap between *P. lima* of the lowlands and *P. maricao* of the mountains. If names are used to differentiate extremes of this sort, they are here available. Whether *P. maricao* is a species, a subspecies, or merely an ecological form remains to be proved. To judge from Figure 4 and Table IV, I am inclined to feel that it should rank as an ecological form.

TABLE IV

PERCENTAGE DISTRIBUTION FOR COLLECTIONS OF *Polydontes lima*
Made in Puerto Rico according to elevations.

| Max. Diam. in mm. | -50′ | | 50′–499′ | | 500′–1499′ | | 1500′– | | Totals | |
|---|---|---|---|---|---|---|---|---|---|---|
| 19 | | | 1 | 0.2 | | | | | 1 | 0.08 |
| 20 | | | 4 | 1.3 | | | 2 | 2.6 | 6 | 0.5 |
| 21 | | | 17 | 2.7 | 1 | 0.7 | 6 | 7.9 | 24 | 1.9 |
| 22 | 2 | 0.5 | 26 | 4.1 | 4 | 2.7 | 10 | 13.2 | 42 | 3.3 |
| 23 | 13 | 3.0 | 39 | 6.0 | 18 | 12.0 | 11 | 14.5 | 81 | 6.3 |
| 24 | 32 | 7.7 | 76 | 12.0 | 39 | 26.0 | 10 | 13.2 | 157 | 12.3 |
| 25 | 68 | 16.3 | 89 | 14.0 | 43 | 28.7 | 8 | 10.5 | 208 | 16.2 |
| 26 | 99 | 23.7 | 78 | 12.2 | 21 | 14.0 | 7 | 9.2 | 205 | 16.0 |
| 27 | 77 | 18.5 | 98 | 15.4 | 12 | 8.0 | 10 | 13.2 | 197 | 15.4 |
| 28 | 63 | 15.1 | 93 | 14.6 | 8 | 5.3 | 7 | 9.2 | 171 | 13.3 |
| 29 | 38 | 9.1 | 75 | 11.8 | 3 | 2.0 | 4 | 5.3 | 120 | 9.4 |
| 30 | 17 | 4.0 | 34 | 5.3 | 0 | 0.0 | 1 | 1.3 | 52 | 4.0 |
| 31 | 7 | 1.7 | 5 | 0.8 | 1 | 0.7 | 0 | 0.0 | 13 | 1.0 |
| 32 | 1 | 0.2 | 2 | 0.3 | 0 | 0.0 | 0 | 0.0 | 3 | 0.2 |
| Totals | 417 | 99.8 | 637 | 100.7 | 150 | 100.1 | 76 | 100.1 | 1280 | 99.8 |

## *Polydontes acutangula* (Burrow)

(Pl. VI, Fig. 10)

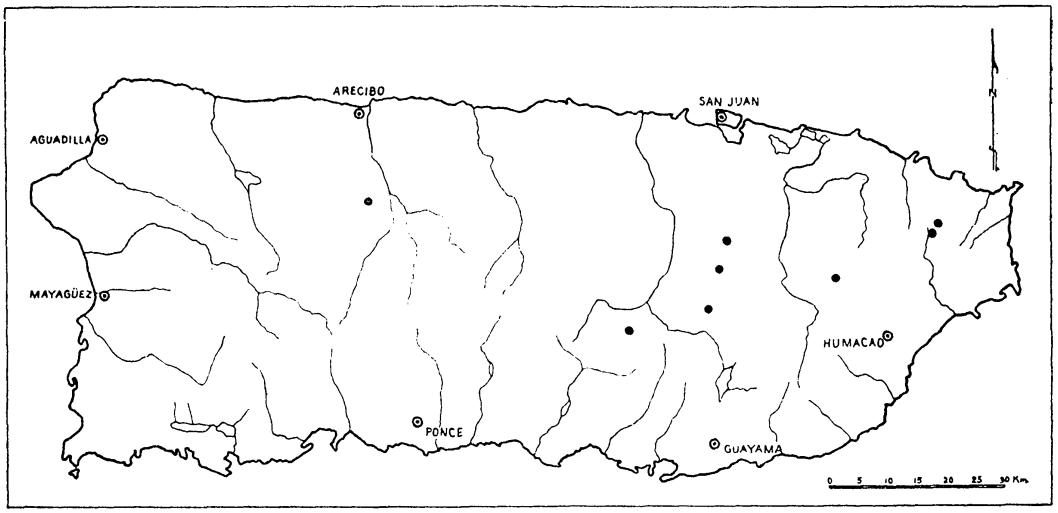
*Helix acutangula* Burrow, *Elements of Conchology,* 1815, pp. 183, 248.

*Helix angulata* Férussac, *Tableaux . . . mollusques . . . Prodrome,* 1821, p. 36, (*nomen nudum*).

*Pleurodonte* (*Polydontes*) *angulata* Férussac, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 381.

*Pleurodonte acutangula* (Burrow), Vanatta, *Nautilus,* 24 (1910): 138.

This species was formerly referred to as *Pleurodonte angulata* (Férussac). In 1911, E. G. Vanatta (1911: 138) showed that *P. angulata* of Férussac was a preoccupied name and hence could not be used for this shell from Puerto Rico. As has been stated by Crosse (1892: 19), this species is very striking in appearance. The animal greatly exceeds the size of its shell, and the yellowish tinge of the exposed body with the black coloration of its head and often with a bright reddish orange border around the foot adds much to make this species strikingly different from others in its native haunts. My records (Map 50) emphasize von Martens' (1877: 348) observa-




MAP 50. Distribution of *Polydontes acutangula.*

tion that *P. acutangula* inhabits mainly the interior of the eastern half of the island. Recently, H. B. Baker added several records worthy of note: two miles south of Old Loiza; southeast of Humacao; limestone hill southwest of San Juan; ten miles south of Arecibo; and summit of Sierra Morales, south of Jayuya. In life *P. acutangula* is arboreal and is most commonly on the branches and leaves of trees in the more wooded parts of the tropical rain forest. In this connection, it may be of interest to add that during a dry period in the El Yunque region *P. acutangula* was collected from the trees, although not in evidence there. An examination of the arboreal bromeliads showed that this species, as well as other members of the *Polydontes* genus living with it in such a forest, goes into the water-filled bracts during drought periods. With the adults, eggs and recently hatched young were secured at the base of these leaves. Baker found that it also aestivates in dead *Cecropia* leaves above the ground.

Almost all the specimens taken in Puerto Rico had the typical acutely angled whorl. Among five specimens collected near the caves at Aguas Buenas there was one which after an injury continued to grow a final whorl that was decidedly rounded rather than angulate.

### *Polydontes luquillensis* (Shuttleworth)

(Pl. VI, Fig. 9)

*Helix luquillensis* Shuttleworth, "Diagnosen . . . , 1854, p. 132.
*Pleurodonte luquillensis* Shuttleworth, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 381.

This species, as implied in its name, has not been found anywhere in Puerto Rico except in the Luquillo Mountains of the extreme eastern end of the island (Map 47). It is truly a mountain form and seems to be restricted to life on branches and leaves of trees in the high tropical rain forest. Of the three large species of this group (*P. carocolla, P. acutangula,* and *P. luquillensis*) commonly in the higher mountain mass around El Yunque, both *P. luquillensis* and *P. acutangula* are comparatively scarce. A fine series was taken during an unusual dry period from the bracts of bromeliads in palm trees, in which the animals had concentrated to withstand the dry conditions. As a rule, however, the rain forest of that vicinity is very wet, and it is difficult to find specimens of *P. luquillensis* moving about actively on the vegetation.

### *Zachrysia auricoma havanensis* Pilsbry

(Pl. VI, Fig. 11)

*Zachrysia auricoma havanensis* Pilsbry, *Proc. Acad. Nat. Sci. Phila.*, 78 (1926): 76, and footnote, p. 77.
*Zachrysia auricoma havanensis* Pilsbry, *Proc. Acad. Nat. Sci. Phila.*, 80 (1928): 601.

So far as can be determined, this is the first time *Zachrysia* has been recorded from Puerto Rico. Pilsbry (1928: 581–606) made a careful study of this genus, and from his paper the following pertinent information has been taken. Originally, species belonging to this genus were common and conspicious snails all over Cuba. Of the several species, *Z. auricoma* and its subspecies *havanensis* seem to be the exception to the rule that most *Zachrysia* in Cuba live in humid forests. Pilsbry (1928: 583) stated:

> [*Z. auricoma*] often lives in country nearly rainless for periods of some months, in places with little shade, such as loose stone walls around gardens or fields; though the shaded slopes of hills or magotes in the low country seem to be its favorite resorts. The hard calcareous epiphragm of this snail probably adapts it to withstand desiccation better than other species.

One could hardly find a better description for the conditions prevailing where this species was taken in Puerto Rico. The distribution records (Map 27) show that in this island it is confined to the small, often exceedingly dry

haystack knolls that jut out of the coastal plain on the north coast between Arecibo and Toa Alta. The plain surrounding these knolls is heavily cultivated for growing sugar cane, pineapple, and in some places citrous fruits. In several instances the aestivating snails were in the soil among the dry limestone rocks at the base of these knolls. At one station a series of *Zachrysia* was found buried in the soil along a fence several hundred yards from such a knoll. It is very likely that this species has been introduced into Puerto Rico within a comparatively recent time. So large a snail would certainly have been discovered by the several naturalists who formerly collected in Puerto Rico. Also, Pilsbry (1926*a:* 76) reported that this same species was introduced from Cuba into Panama; Clench (1938*b:* 330) reported a related form, *Zachrysia provisoria* (Pfeiffer), from several of the Bahama Islands. Clench stated: "It has so far only advanced in the immediate vicinity of settlements. Another form (*Z. havanensis*) has been introduced in Panama and Yucatan, both forms appear to colonize new territory readily." Bequaert and Clench (1936: 64) also reported it as introduced into the Yucatan region of Mexico.

FAMILY CEPOLIDAE

## *Cepolis musicola* (Shuttleworth)

(Pl. VI, Fig. 12)

*Helix musicola* Shuttleworth, "Diagnosen . . . ," 1854, p. 130.

*Helix musicola* Shuttleworth, Tryon, *Manual of Conchology,* 2d ser., 3 (1887): 97, Pl. 8, Fig. 66.

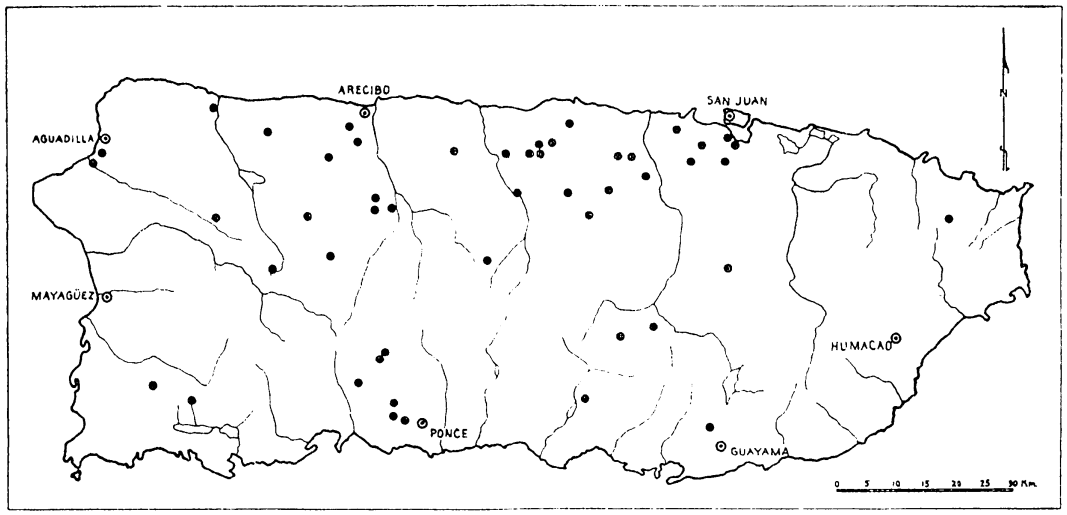
*Thysanophora musicola* Shuttleworth, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 379.

*Cepolis (Hemitrochus) musicola* (Shuttleworth) H. B. Baker, *Nautilus,* 56 (1943): 82.

*Cepolis (Euclastaria) musicola* (Shuttleworth) H. B. Baker, *Nautilus,* 56 (1943): 85.

Originally, Shuttleworth (1854: 130–31) described two species, *Helix euclasta* and *Helix musicola,* the type of *musicola* being from Puerto Rico, and the type of *euclasta* from St. Thomas. A variety of *H. euclasta,* supposedly not typical, was reported by him from the region of Ponce in Puerto Rico. Although it will be necessary to make a more careful study of this matter, using the type material for reference, it did not seem from the series I took in Puerto Rico that *C. musicola* and *C. euclasta,* assuming that a form of *C. euclasta* occurs on the island, could be separated one from the other. Consequently, both species are considered here as one. The form which approaches *C. musicola* as that species is defined, that is, a form smaller in size with heavy growth ridges, seems most prevalent in the wet, vegetation-covered limestone outcrops of the uplands. This more or less typical *C. musicola* form was also found in less disturbed parts of the lowland. Along the drier parts of the coastal plain the larger form with a smoother surface occurs, which may be referred to *C. euclasta.*

For the present, it seems best to present these two nominal species under a single heading because the separation made has been a somewhat mechanical one with considerable doubt as to whether some specimens should rightfully be grouped with one or the other. If one has typical forms, the problem is not so great, but on the coastal plain there are intergradations which could be carefully analyzed, perhaps anatomically as well as ecologically, to test whether there are actually one or two species involved. Since *C. euclasta,* if it is a genuine species, occupies the coastal fringe of the north and south coastal plain, there is a possibility that *C. musicola* must be considered the normal phase in Puerto Rico with *C. euclasta* as a form of it. My records (Map 51), however, show few collections for the east end of




MAP 51. Distribution of *Cepolis musicola.*

the island. The type of *C. musicola* was taken by Blauner from Luquillo, and the forms are widely distributed throughout the island. It is interesting to note that E. von Martens (1877: 347) referred coastal plain forms from Aguadilla and Quebradillas to *Helix musicola* rather than to *H. euclasta,* placing the latter in his list of species not found in Puerto Rico by Gundlach. Baker (in notes at hand) gave the following ecological data: "Ground and weak climber, under leaves and rocks, widely distributed, 0–3000 ft."

## *Cepolis squamosa* (Férussac)

(Pl. VI, Fig. 13)

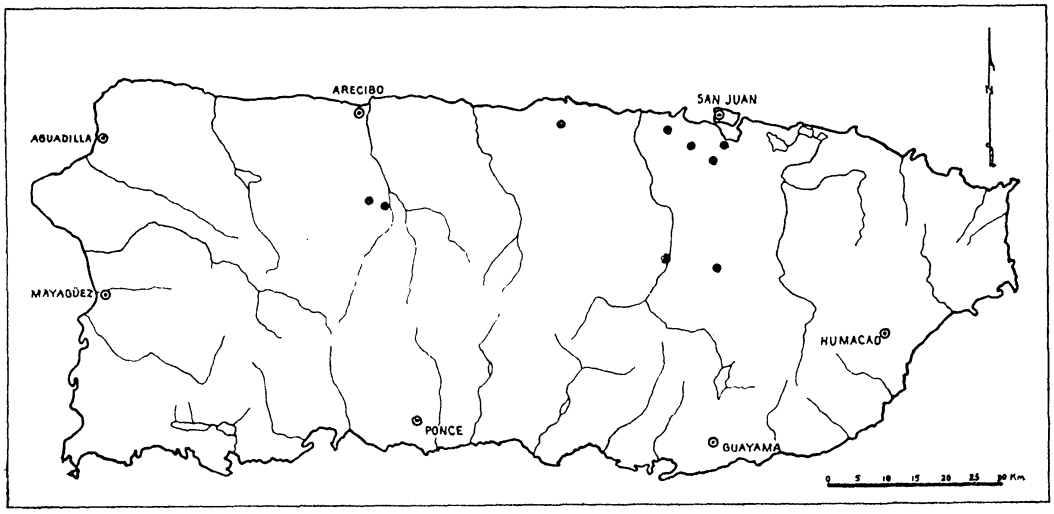
*Helix squamosa* Férussac, *Tableaux . . . mollusques . . . Prodrome,* 1821, p. 36; Pl. 41, Fig. 3.

*Cepolis squamosa* Pilsbry, *Manual of Conchology,* 2d ser., 5 (1889): 95, Pl. 56, Figs. 20–22.

*Cepolis squamosa* Shuttleworth, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 380.

*Cepolis (Bellacepolis) squamosa* (Férussac) H. B. Baker, *Nautilus,* 56 (1943): 82, 86.

This is a relatively rare species in Puerto Rico. Most of the colonies (Map 52) were taken along the northern coastal plain and the foothills just south of it. It was never seen in the Cordillera Central. Blauner (Shuttleworth, 1854: 135) found it to be rare near Luquillo, which is farther east than Map 52 indicates, but still shows the species as inhabiting the northern




MAP 52. Distribution of *Cepolis squamosa*.

coastal plain. E. von Martens (1877: 348) called attention to the fact that Stahl, Krug, Mauge, and Moritz all reported *C. squamosa* from Puerto Rico, but none of them gave exact locality data. Moritz, however, mentioned that his specimens were taken from beneath bark of trees. Blauner collected *C. squamosa* around banana trees under dead leaves. My best series (not alive) was taken among leaf mold and debris in a large crevice of a limestone cliff near the Guajataca forestry station some seventeen kilometers up the canyon of Rio Grande de Arecibo. H. B. Baker (1943*a*: 86–87) described the anatomy of a specimen and stated:

> One adult animal was collected September 2, after a search of almost a month, in dead *Cecropia* leaves caught in the crotch of a small tree, about five feet up, near Old Loiza (EN1), Puerto Rico. [Other records are:] Very dry hills near Pt. Barrancas; dryish to rather heavy woods on limestone hills about 2 miles south of Cataño; about 10 miles south of Arecibo in rich brush on little limestone knobs between road and west bank of Rio Grande de Arecibo; and same region but in rich woods at base of cliffs beyond east bank of Rio Grande de Arecibo.

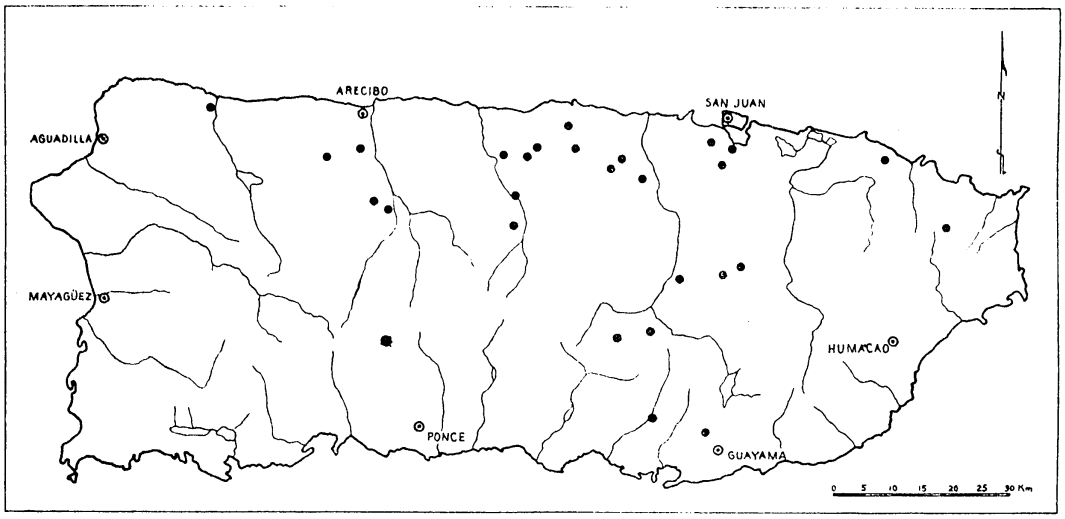
## *Cepolis boriquenae* H. B. Baker

(Pl. VI, Fig. 14)

*Cepolis* (*Plagioptycha*) *boriquenae* H. B. Baker, *Nautilus*, 53 (1940): 107.
*Cepolis* (*Levicepolis*) *boriquenae* H. B. Baker, *Nautilus*, 56 (1943): 82.
*Cepolis* (*Levicepolis*) *boriquenae* H. B. Baker, *Nautilus*, 56 (1943): 88.

Recently, H. B. Baker (1940*a*: 107) gave the name *C. boriquenae* to

specimens from Puerto Rico which previously had been called *C. diaphana.* This species appears to be most common throughout the eastern half of the island (Map 53) with an extension of its range along the northern coastal




MAP 53. Distribution of *Cepolis boriquenae.*

plain. Blauner (Shuttleworth, 1854: 132) collected it at Humacao and Rio Blanco. Although *C. boriquenae* is much more common among limestone outcrops of the lower parts of the island it does inhabit the mountainous regions as well. H. B. Baker (1943*a:* 88) collected specimens used for dissection "mainly in dead *Cecropia* leaves caught in vines, and shrubs, in the canyon of Rio Grande de Arecibo (PN1), Puerto Rico." Additional records given by Baker are "dryish hills on third line of hills, about two miles south of Old Loiza; southeast of Humacao; 2 mi. south of Cataño; south of Palo Seco; top and southeast side of Montoso."

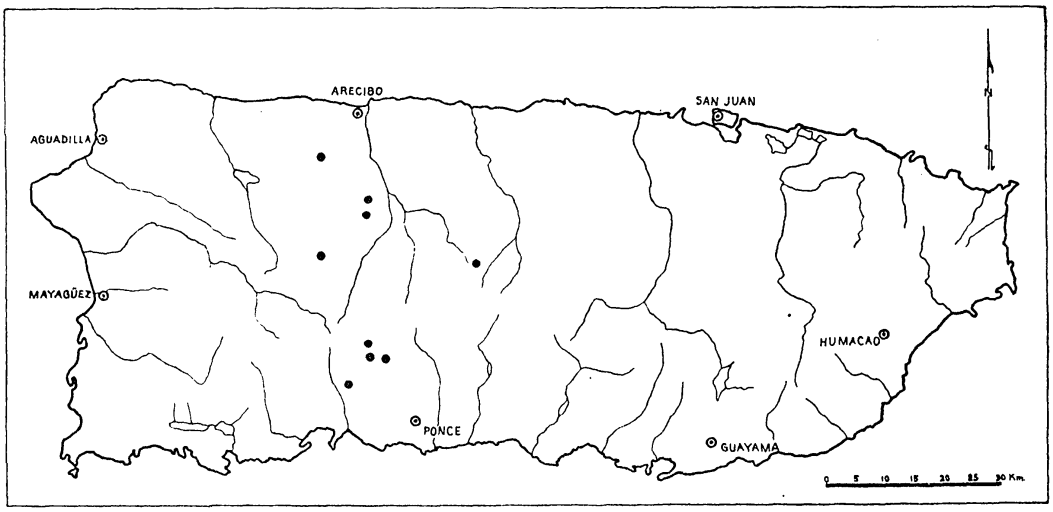
## *Cepolis dermatina* (Shuttleworth)

(Pl. VI, Fig. 15)

*Helix dermatina* Shuttleworth, "Diagnosen . . . ," 1854, p. 133.
*Cepolis dermatina* Tryon, *Manual of Conchology,* 2d ser., 5 (1889): 50, Pl. 10, Fig. 93.
*Cepolis dermatina* Shuttleworth, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 380.
*Cepolis (Jeanneretia?) dermatina* (Shuttleworth), H. B. Baker, *Nautilus,* 56 (1943): 88.

In contrast to *C. boriquenae* this species is mainly western in its distribution (Map 54). Shuttleworth's type, however, was collected by Blauner from banana trees in the region of Luquillo. It is far more common in the higher mountainous regions than on the coastal plain. A species, *C. angulifera,* described by von Martens (1877: 347) seems to be a synonym of *C. dermatina,* but the type has not been seen, which makes it difficult to appreciate fully just what it was that von Martens described. His figure

agrees with specimens of *C. dermatina* taken in extreme western Puerto Rico, but not with Shuttleworth's description, based on shells from Luquillo. There is a possibility that *C. angulifera* may eventually be established as a subspecies. H. B. Baker (1943*a:* 88) also found this species "in dead *Cecropia* leaves caught in vines and trees, near Adjuntas (PR-4), Puerto Rico." Additional records are given by Baker for the species: "Damp rain-forests of main range, between Arecibo and Ponce; old coffee with




MAP 54. Distribution of *Cepolis dermatina.*

brush, about 1 mile from Adjuntas towards Guazas dam." For the subspecies he listed: "Near west end of Sierra Calderon; sparse woods in coffee, top and southeast side of Montoso; heavier forest west of Santa Ana peak."

FAMILY BULIMULIDAE

## *Bulimulus exilis* (Gmelin)

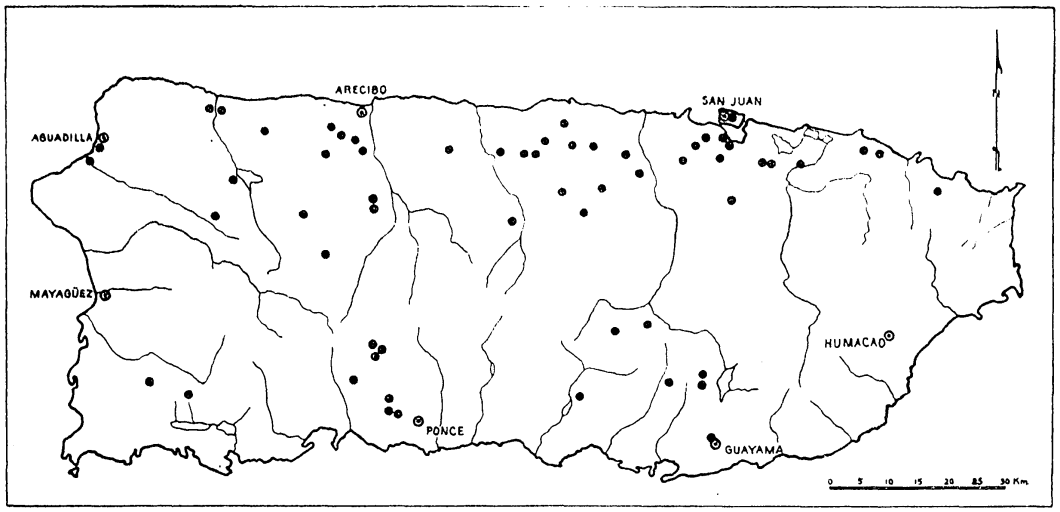
(Pl. VII, Figs. 1*a, b, c, d*)

*Helix exilis* Gmelin, *Systema naturae,* 1792, p. 3668.
*Bulimulus exilis* Gmelin, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 378.

With *Subulina octona, B. exilis* is perhaps one of the most adaptable species in Puerto Rico. Like *S. octona,* it seems to thrive particularly where human activities have eliminated other less tolerant forms. It was always of considerable interest to find *B. exilis* in conspicuous places aestivating on the walls of prominent public buildings and homes. It was also a common snail among the dead leaves and shrubs of the public parks. Map 55 indicates that the species is widely distributed on the island. Curiously, forested regions of the uplands that are not subject to cultivation, such as El Yunque, do not yield this otherwise common snail.

Perhaps because of its presence in many and varied environments, *B.*

*exilis* has proven almost as variable as the situations under which it lives. Ordinarily, specimens vary from a plain white, grayish, or light brown to forms which have single, double, or triple dark brown bands. The banded forms, at times, are almost completely brown or black. A variety *eyriesii* (Drouet) is recognized for specimens which are supposedly a light uniform white or brown and are more conoid and thinner than is typical *B. exilis*. Every possible intergradation appears, and it seems most unnatural to separate mechanically these varied forms to satisfy an unreasonable scheme in taxonomy. If there are any basic reasons for separating subspecies among these variables, the widely tolerant *B. exilis* might lend itself advantageously to experimental breeding to determine the relative static value of the characters which now seem unstable. Among thousands of specimens




MAP 55. Distribution of *Bulimulus exilis*.

taken from the lower sides of large slabs of limestone in a cultivated plot north of Morovis, a single scalariform specimen (Fig. 1*b*) was collected. Although a careful search was made for more anomalous specimens, no others were found.

## *Bulimulus diaphanus* (Pfeiffer)

*Bulimus diaphanus* Pfeiffer, *Proc. Zool. Soc.*, 1854, p. 125.

*Bulimulus diaphanus* Pfeiffer, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 378.

## *Bulimulus fraterculus* (Férussac)

*Helix* (*Cochlogena*) *fraterculus* Férussac, *Tableaux . . . mollusques . . . Prodrome*, 1821, p. 395.

*Bulimus Fraterculus* Shuttleworth, "Diagnosen . . . ," 1854, p. 137.

*Bulimulus fraterculus* Crosse, *Journ. de conchyl.*, 40 (1892): 23.

## *Bulimulus psidii* von Martens

*Bulimus* (*Eudioptus*) *psidii* E. von Martens, *Jahrb. d. deutschen malak. Gesellsch.*, 4 (1877): 351, Pl. 12, Fig. 6.

*Simpulopsis psidii* E. von Martens, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 377.

## *Drymaeus virgulatus* (Férussac)

(Pl. VIII, Fig. 3)

*Helix* (*Cochlogena*) *virgulata* Férussac, *Tableaux . . . mollusques . . . Prodrome*, No. 396 (1822): 54.

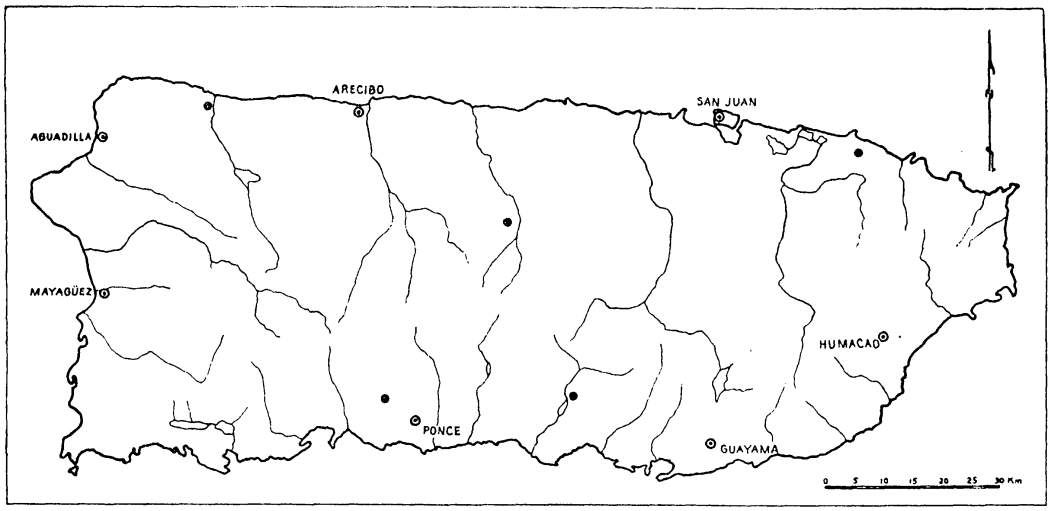
*Bulimulus virgulatus* Férussac, von Martens, *Jahrb. d. deutschen malak. Gesellsch.*, 4 (1877): 350.

*Helix elongata* Bolten, *Museum Boltenianum*, 1st ed., 1798, p. 107.

*Drymaeus elongatus* (Bolten), Pilsbry, *Manual of Conchology*, 2d ser., 12 (1899): 23–27.

*Drymaeus elongatus* Bolten, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 379.

In Puerto Rico, *D. virgulatus* is relatively local. Only six lots were taken (Map 56), and these were largely confined to the fringe of the island




MAP 56. Distribution of *Drymaeus virgulatus*.

around the coastal plain. The lot taken south of Ciales contains but a single specimen, which appears weathered enough to approach the fossil state. A great deal of color variation was found among the other lots. In this connection, Tryon (1899: 26) stated: "None of the patterns of coloring seem to be constant or sharply restricted geographically, although frequently the specimens from one special locality are alike. Thus of 34 specimens from Porto Rico there are 7 uniform white, 5 red, 2 red with bands, 5 whitish with interrupted bands, 10 with narrow streaks, and the rest various transitions." E. von Martens (1877: 350) reporting on Gundlach's collection gave a number of specific localities which may well be added to those col-

lected recently. He, too, noted that this species inhabited coastal regions such as "Manati, Arecibo, Quebradillas, Guanica (in the south) and in the interior around Utuado." In these series, von Martens also noted a wide variation in color. With regard to the two lots taken somewhere in the interior, reported by von Martens from Utuado and on the accompanying map as from Ciales, it should be pointed out that at both stations a broad river flood plain sweeps into the interior, so that it is possible that these colonies are established on a natural extension of the coastal plain. At the extreme eastern end of the island Blauner (Shuttleworth, 1854: 136) found *D. virgulatus* rarely near the coastal towns of Fajardo and Ceiba. H. B. Baker (1924: 80–85) gave an interesting account of the variation of this species as it occurs in the Dutch Leeward Islands. This snail is apparently arboreal in its habits, living on the branches and trunks of the larger trees.

## *Drymaeus liliaceus* (Férussac)

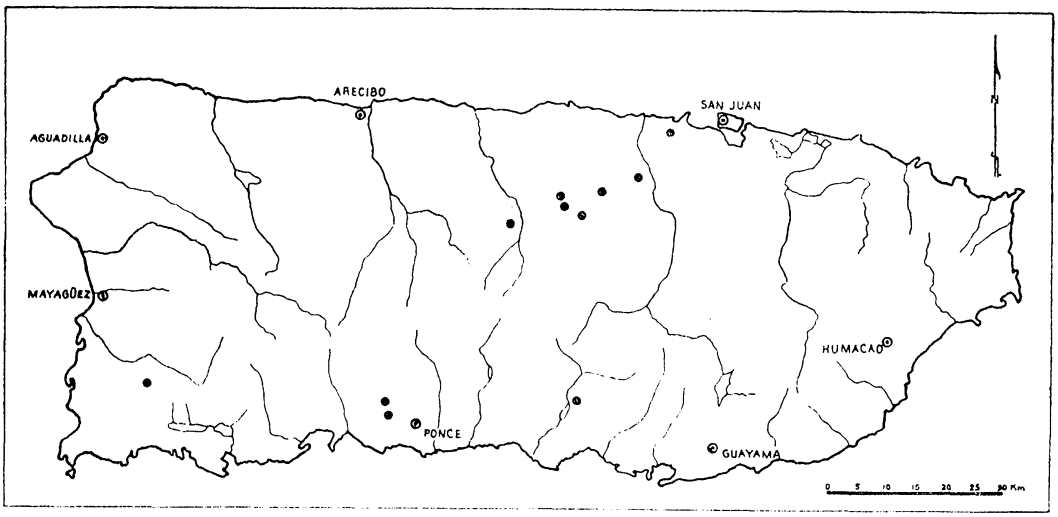
(Pl. VIII, Fig. 4)

*Helix* (*Cochlogena*) *liliacea* Férussac, *Tableaux . . . mollusques . . . Prodrome,* 1821, p. 54, Pl. 142B, Fig. 11.

*Drymaeus liliaceus* (Férussac) Pilsbry, *Manual of Conchology,* 2d ser., 12 (1899): 10–11.

*Drymaeus liliaceus* Férussac, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 379.

This beautiful, white snail was relatively local in its occurrence in Puerto Rico. The finest series were collected in the vicinity of Morovis, where specimens were gathered high up on the branches of a tree, presumably the "Maga" tree (*Thespesia grandiflora* F. DC., according to Urban's *Flora Portoricensis*). To judge from the limited work recently accomplished, this species is mostly in the north-central limestone region of the northern coastal plain and in a similar area of the southwestern coastal plain. Earlier rec-




MAP 57. Distribution of *Drymaeus liliaceus*.

ords extend its distribution to include the eastern plain (Las Piedras and Humacao, taken by Blauner) and the northwestern region (Utuado and Quebradillas, taken by Gundlach). The arboreal habits of *D. liliaceus* may be responsible for the scattering of the records which are at present available. Perhaps, with better knowledge of its normal habitat, there will be a better appreciation of the limiting factors in its distribution. It does seem certain, however, that the species is not usually in forested regions at high altitudes. The regions indicated for its range (Map 57) are ones which possess an ample supply of outcropping limestone.

### *Drymaeus hjalmarsoni* (Pfeiffer)

*Bulimus hjalmarsoni* Pfeiffer, *Malak. Blätt.*, 3 (1856): 51 (unfigured).

*Drymaeus hjalmarsoni* (Pfeiffer), Pilsbry, *Manual of Conchology*, 2d ser., 12 (1899): 7–8.

*Drymaeus hjalmarsoni* Pfeiffer, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 378.

### *Gaeotis nigrolineata* Shuttleworth

(Pl. VIII, Fig. 5)

*Gaeotis nigrolineata* Shuttleworth, "Diagnosen . . . ," 1854, p. 127.

*Gaeotis flavolineata* Shuttleworth, Dall and Simpson "The Mollusca of Porto Rico," 1901, p. 377.

A single specimen was taken on a bridge along the road approaching El Yunque. Crespo, who found it, at first assumed it to be a mass of algal material. The rather large snail is yellowish green, with a reduced shell buried in the middle of its back. H. B. Baker informed me that these animals apparently are almost wholly arboreal, living mainly on palm leaves in rich forest. In addition to the records given by Shuttleworth (1854: 127–28) to establish it as inhabiting the eastern mountain range, there are records of its occurrence in the forested mountain regions of the western mountain mass. Baker reported it from "the heavier forest on ridge between CCC camps Buena Vista and Santa Ana."

Two other species have been described. Until proved synonyms, they merit the benefit of the doubt.

### *Gaeotis albopunctulata* Shuttleworth

*Gaeotis albopunctulata* Shuttleworth, "Diagnosen . . . ," 1854, p. 36.

*Gaeotis albopunctulata* Shuttleworth, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 378.

### *Gaeotis malleata* Pilsbry

*Gaeotis malleata* Pilsbry, *Manual of Conchology*, 2d ser., 12 (1899): 230, Pl. 62, Figs. 36–40.

FAMILY UROCOPTIDAE

## *Brachypodella portoricensis* (Pfeiffer)

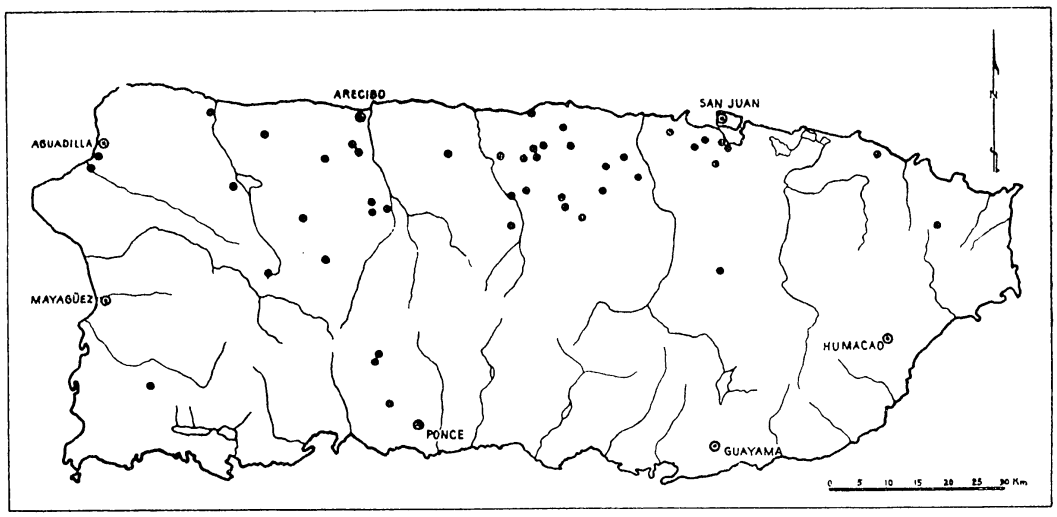
(Pl. VIII, Fig. 7)

*Cylindrella portoricensis* Pfeiffer, *Zeitschr. f. Malak.*, 9 (1852): 151; Martini and Chemnitz, *Systematisches Conchylien Cabinet, Cylindrella*, Pl. 4, Figs. 14–15.

*Brachypodella portoricensis* Pfeiffer, Pilsbry, *Manual of Conchology*, 2d ser., 16 (1904): 48–49.

*Brachypodella portoricensis* Pfeiffer, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 377.

This is the largest species of *Brachypodella* in Puerto Rico, and it is also the most widespread (Map 58). In the northern and eastern parts




MAP 58. Distribution of *Brachypodella portoricensis*.

of the island *B. portoricensis* covers an area similar to that occupied by *B. riisei*, but in the southwest and west it seems to cut across the island in a more general way. Like most species of *Brachypodella*, this one is usually associated with limestone outcrops on which it lives. This habitat restriction partly accounts for its abundance in the many limestone knolls between Manati, Morovis, and San Juan. On the whole, *B. portoricensis*, although not common at high elevations, seems to occur at somewhat higher elevations than do either *riisei* or *pallida*. It is somewhat surprising that this species lives at greater altitudes and ranges across the western third of the island, since both *B. riisei* and *pallida* are largely confined to the coastal plain and foothills. Its relationships have been expressed by Pilsbry (1906: 49). He stated that *B. portoricensis* is related to *B. angulifera* of eastern Cuba and *B. imitatrix* of Haiti, "but is usually larger than either, though the smallest Porto Rican specimens could not, I think, be separated with any certainty from the Haitian and Cuban shells." Baker observed that *B. portoricensis* was a "very poor climber, mainly on rock-bases in northern limestone, 0–300 ft."

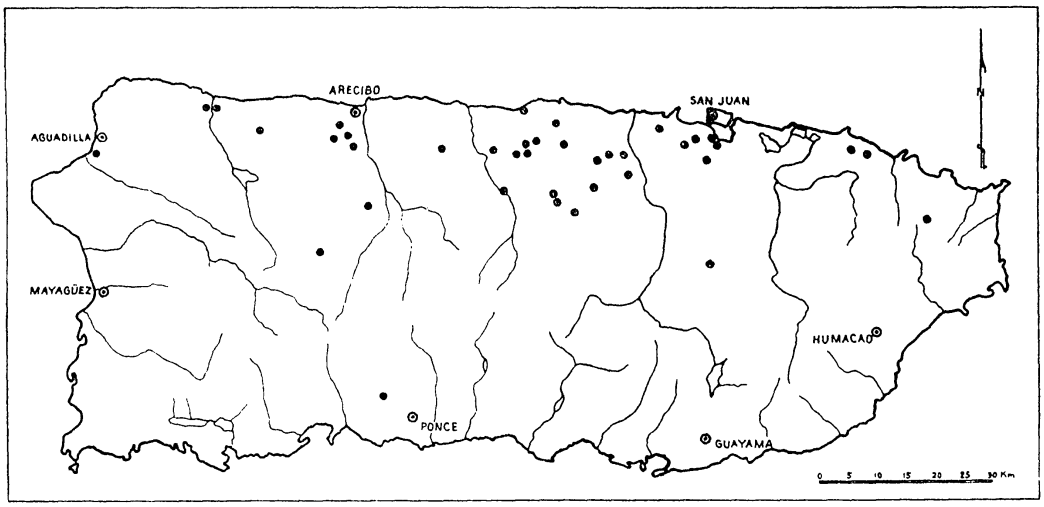
## *Brachypodella riisei* (Pfeiffer)

(Pl. VIII, Fig. 6)

*Cylindrella riisei* Pfeiffer, *Zeitschr. f. Malak.*, 9 (1852): 133; Martini and Chemnitz, *Systematisches Conchylien Cabinet, Cylindrella,* Pl. 5, Figs. 18–20.

*Brachypodella riisei* Pfeiffer, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 377.

One of the most common species among limestone outcrops and knolls along the northern coastal plain is *B. riisei.* Only a single record (Map 59)




MAP 59. Distribution of *Brachypodella riisei.*

was established along the south coast, near Ponce, and Baker also collected it at Las Peñones, south of the town of Cabo Rojo. E. von Martens (1891: 132) reported that Sintenis collected it at Peñuelas. Actually, *B. riisei* is abundant along the northern coastal plain and is particularly an inhabitant of the limestone knolls between Manati and San Juan. Baker found this animal, as compared with the other species of the genus in Puerto Rico, "usually lower on limestone faces, 0–300 ft."

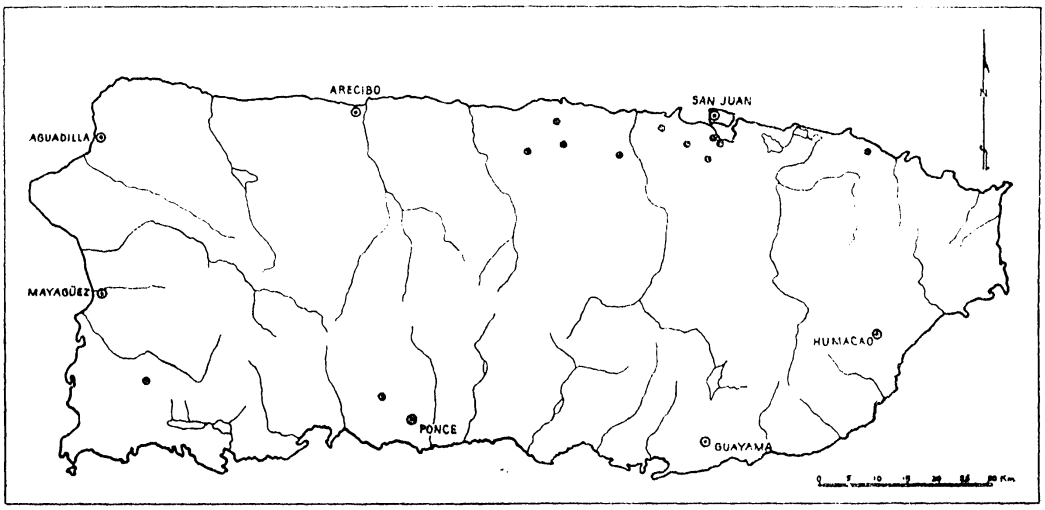
## *Brachypodella pallida* ('Guilding' Pfeiffer)

(Pl. VIII, Fig. 8)

*Brachypus pallidus* Guilding (MS); *Cylindrella pallida* Pfeiffer, *in* Philippi, *Abbildungen und Beschreibungen Conchylien,* 2 (1845): 52, Pl. 2, Fig. 14.

*Brachypodella pallida* Guilding, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 377.

This species is far less common in Puerto Rico than is either *B. portoricensis* or *B. riisei.* Distributionally, it has a characteristic pattern with two definite centers of abundance. The region of the prominent limestone "haystack" knolls situated between Manati and San Juan contains many colonies of the *B. pallida* (Map 60). It will be noted that in that region




MAP 60. Distribution of *Brachypodella pallida.*

this species does not range as far inland as does *B. riisei,* with which it is often associated. In the southwest (Map 60) several localities may be added to the few given. Sintenis collected it in the region of Peñuelas. Baker found it at three additional localities:

Cerro Capron, semi-desert limestone hills east of entrance to Guanica Harbor; dry woods on hills which are no longer capped with limestone, just west of Rio Loco, south of Yauco-Sabana Grande road; dry brush on limestone capped hills (los Peñones) south of town of Cabo Rojo.

Baker observed that this species was the "best climber" of the three species of *Brachypodella* in this island, 0–450 ft.

Conchologically, *B. pallida* appears to be closely related to *B. riisei.* In the field it was observed that *B. pallida* inhabited dry and porous outcrops of limestone. In this connection, it would be of interest if one could determine whether the larger and coarser ribs of *B. pallida* were developed in a strain of *B. riisei* which was exposed for many generations to more xeric conditions.

## *Pseudopineria viequensis* (Pfeiffer)

(Pl. VII, Fig. 3)

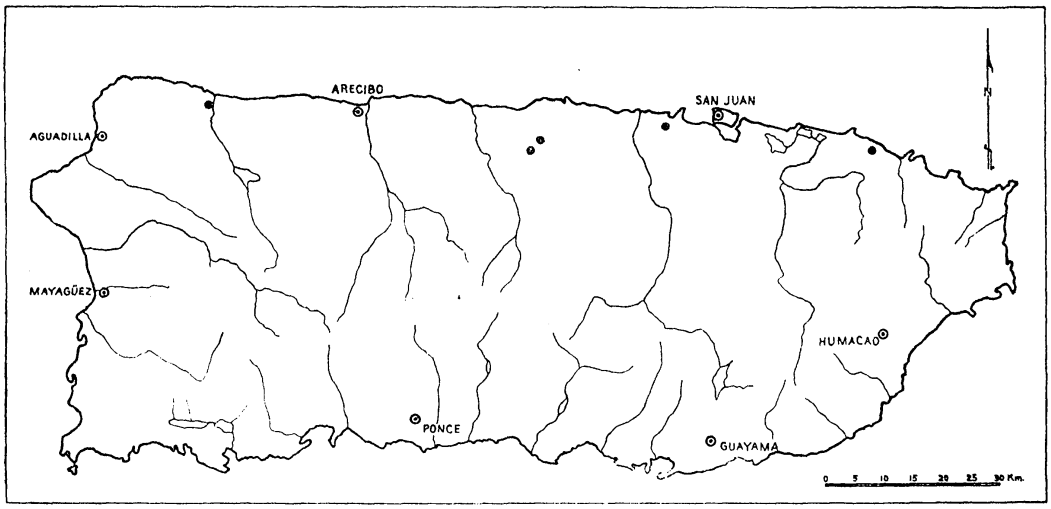
*Bulimus viequensis* Pfeiffer, *Malak. Blätt.,* 3 (1856): 46; Pfeiffer, *Novitates Conchologicae,* 3: Pl. 93, Figs. 39–41.

*Pineria viequensis* Pfeiffer, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 376.

*Pineria viequensis* (Pfeiffer), Pilsbry, *Manual of Conchology,* 2d ser., 16 (1904): 111–12.

Because of radular differences, Aguayo (1938*a:* 71–73) separated his new genus, *Pseudopineria,* from the old genus *Pineria* and showed that the two genera do not belong in the same subfamily. According to Pilsbry (1904: 109): "The genus *Pineria,* at least as represented by *P. viequensis,*

is closely related to *Brachypodella,* and probably branched off from the Urocoptid stock at about the same time." Although originally described from the neighboring island of Vieques, where the type material was collected by Riise, *Pseudopineria viequensis,* according to Crosse (1892: 25), was not previously reported from Puerto Rico. Its presence is now well established on this island (Map 61). *P. viequensis* appears to be restricted




MAP 61. Distribution of *Pseudopineria viequensis.*

to limestone knolls extending along the edge of the north coast. This habitat restriction is similar to that of *Pineria beatheana,* recorded by Pilsbry (1904: 109) as "inhabiting the coastal belt of raised reefs."

In considering the evolution of the Urocoptidae, Pilsbry (1904: xv–xvi) pointed out that the tendency to an uncoiled last whorl is common among members of this family and is an indication of racial old age. He continued: "This tendency is almost universal in the Urocoptidae, but some otherwise specialized genera, such as *Pineria,* seem to have passed through this stage and regained a more primitive form, judging from the ancestry indicated by the anatomy of *Pineria viequensis.*"

There is evidence according to Vaughn (1918) and Lobeck (1922: 346–47) that there was a raising and lowering of sea level in this whole region due to "the withdrawal of water in the Pleistocene ice epoch to form the great continental glaciers and the raising of sea level after each epoch through the melting of the glaciers." A fluctuation of some twenty fathoms is believed to have occurred. A reduction of the strand lines by this amount could connect Vieques with Puerto Rico, thus permitting the present pattern in the distribution of this species on this island (Lobeck, 1922: 373).

## *Macroceramus microdon* (Pfeiffer)

(Pl. VII, Figs. 2*a, b, c*)

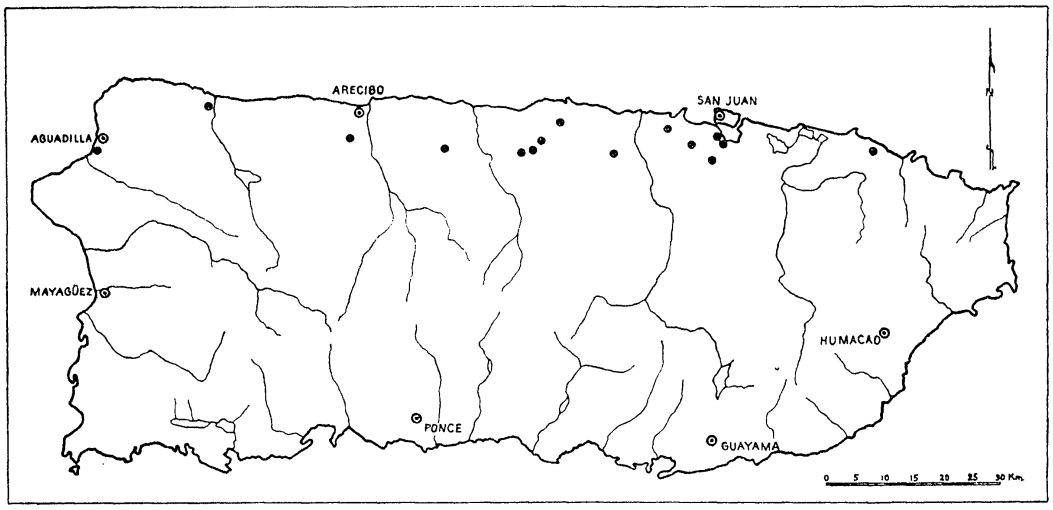
*Bulimus microdon* Pfeiffer, *Proc. Zool. Soc.,* 1851, p. 261.

*Macroceramus microdon* Pfeiffer, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 377.

*Macroceramus microdon* (Pfeiffer), Pilsbry, *Manual of Conchology*, 2d ser., 16 (1904): 115–17.

Three names have been given to the forms of *Macroceramus* from Puerto Rico. Shuttleworth (1854: 145) designated one form "Var. ? $\beta$" under *M. microdon.* E. von Martens (1877: 352) after making an effort to establish that *M. johannis* should probably be synonymized with *M. microdon,* added that a large specimen which is similar to the one designated as "Var. ? $\beta$" of Shuttleworth might well be differentiated and named the variety *shuttleworthi* under *M. microdon.* Baker stated that the specimens he collected "are what Pilsbry (Manual, 16, pl. 24, figs. 72–74) called *M. microdon shuttleworthi* Martens and it is at least a distinct subspecies, distinguished by its more regularly and closely spaced growth-threads."

*M. microdon* (Map 62) was relatively common along the north coast,




MAP 62. Distribution of *Macroceramus microdon.*

where it was most prevalent among the small limestone knolls along the coastal plain. This species also inhabits the southwestern coastal limestone. In addition to the two southern records given, Baker established the following record: "Dry brush on limestone capped hills (Los Peñones) near quarry, about 2 miles southwest of Escuela Manuel Corchado and south of Cabo Rojo town."

## *Microceramus guanicanus* H. B. Baker

(Pl. VII, Fig. 4)

*Microceramus guanicanus* H. B. Baker, *Notulae Nat.*, 88 (1941): 5–6, Fig. 7.

This species was recently described by Baker, who collected it in "Cerro Capron, on coastal limestone hills east of entrance to Guanica Harbor."

## *Cerion crassilabris* ("Shuttleworth" Sowerby)

(Pl. VII, Fig. 5)

*Pupa crassilabris* Sowerby, *in* Reeve, *Conchologia Iconica,* 20 (1875): Pl. 2, Fig. 14.
*Pupa striatella Férussac* MSS *in* Guérin, *Iconium du règne animal, Mollusques,* 1832, p. 16, Pl. 6, Fig. 12.
*Cerion striatella* (Férussac) Guérin, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 376.
*Cerion crassilabre* Sowerby, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 376.

Animals belonging to this genus have been collected in Puerto Rico mainly along the coast in the southwestern part of the island. Pilsbry (1901–2: 193) stated: "This species is quite distinct by its exceedingly obtuse apex." He has also noted (1901–2: 278) that Dall and Simpson's record of *Cerion striatellum* in Puerto Rico is actually *Cerion crassilabris.*

In Puerto Rico the following localities have been cited: Shuttleworth (1854: 145) gave Ponce; von Martens (1877: 350) cited Boqueron (southwest corner of the island); Dall and Simpson (1901: 376) reported Cabo Rojo Light; and H. B. Baker (in notes kindly loaned to me) added "Cerro Capron, semi-desert limestone hills east of entrance to Guanica Harbor; east of Tallaboa, subarboreal, seaward slope of southern limestone." Two additional records in the collections of the Museum of Comparative Zoology at Harvard are Ensenada Point, Guanica; and Mayaguez.

### FAMILY CLAUSILIIDAE

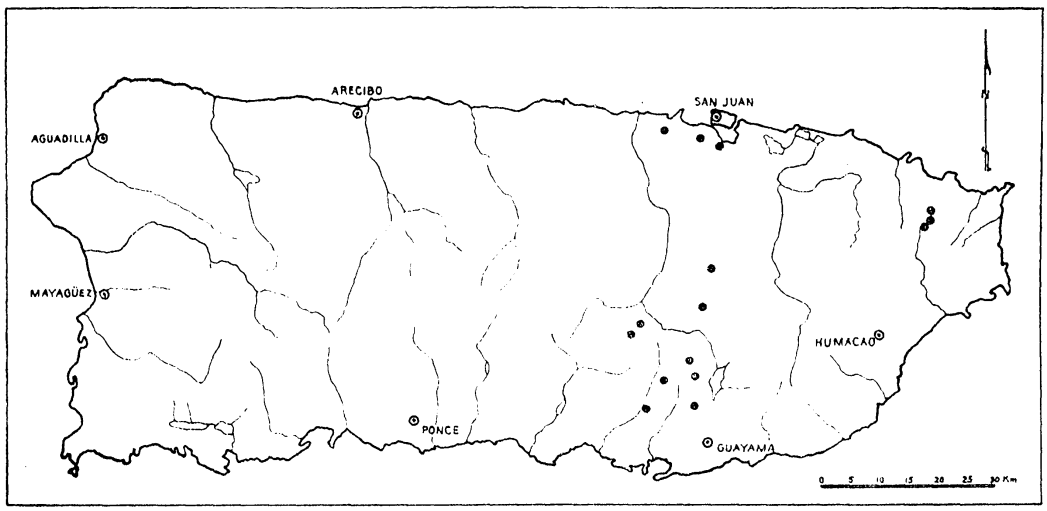
## *Nenia tridens* (Schweigger)

(Pl. VII, Figs. 6*a*, *b*)

*Turbo tridens* Chemnitz, *Systematisches Conchylien Cabinet,* 9 (1786): Fig. 957.
*Clausilia tridens* Chemnitz, Crosse, *Journ. de conchyl.,* 40 (1892): 32.

As indicated by Crosse (1892: 32), *N. tridens* is of considerable interest, since it is the only member of the clausilid group in Puerto Rico. The family is, however, well established in South America. Pilsbry (1926*b:* 9) stated: "The sixty-four American species of this family are now classified in three genera, *Nenia, Peruinia* and *Temesa,* most of them being comprised in *Nenia.*" Lists of Puerto Rican shells prior to the turn of the century refer *N. tridens* to the genus *Clausilia.* Jousseaume (1900) and O. Boettger (1909) placed it in the genus *Nenia.* With the exception of Puerto Rico, *N. tridens* was not found in any of the other islands of the Greater Antilles until Rehder (1939: 171–73) recently described a new species from Mount Rochelle in southern Haiti. Reference to the zoogeographical implications will be made in another section.

It inhabits (Map 63) only the eastern third of the island, where it was particularly abundant at high elevations. Usually, few specimens were




MAP 63. Distribution of *Nenia tridens*.

taken at lower altitudes. Apparently, a good stand of timber in a reasonably undisturbed region produces the optimum conditions for *N. tridens*. In such a favorable habitat hundreds of specimens are often found attached to bark on trunks of trees. The thick green algal coating which often covers both the specimens and the bark on which they live makes a close examination necessary in order to see *N. tridens* in its normal habitat. Baker has summarized the habits as follows: "Subarboreal, mainly on shrubs and vines, almost never on rock faces, forests of east end, 0–2700 feet."

## FRESH-WATER SPECIES

The fresh-water mollusks of Puerto Rico have not received the attention they deserve. The lack of interest in this fauna is perhaps partly due to the relative scarcity of the species. For reasons already given the best collecting appears to be in the lowland parts of the various drainage systems—the very regions where schistosome cercariae are apt to be common. The necessity of caution to the extent of devising special methods for collecting specimens in such dangerous areas poses a genuine obstacle to those attempting to amass a substantial amount of material for research. If to these considerations is added the fact that most of the streams along the coastal plains have been considerably altered by irrigation projects, there appears to be reason for the lack of interest in the fresh-water shells.

During my first visit with Dr. W. A. Hoffman I was impressed with his anxious inquiry as to whether I was aware of the necessity for caution when collecting in the fresh waters of the island. Because of his broad experience with schistosomiasis or bilharziasis, he fully appreciated the need for precautions when working in the field. One precaution suggested by him is worth mentioning for the benefit of those who may wish to collect fresh-

water shells. It has been shown experimentally that the schistosome cercariae start actively burrowing when the water on the exposed skin begins to dry. An application of alcohol (70 per cent or stronger) within one-half hour after exposure will kill any cercariae which are attempting to burrow into the skin. It is, therefore, important that one carry a supply of alcohol into the field for this purpose. Córdova-Márquez and I worked in waders and wore rubber gloves when working in a presumably infected pool near Guayama. We found this equipment uncomfortable when busily moving about under a tropical sun, but the water that bathed our bodies came from within, and we had the peace of mind that goes with knowing we were not being exposed to infection.

Perhaps no island among the Greater Antilles has been studied by a greater number of competent malacologists than Cuba has. Yet, it has been only a few years since C. G. Aguayo (1938) presented an interesting and informative analysis of the fresh-water mollusks of that island. Many of the principles set forth by Aguayo for Cuba also apply to Puerto Rico. Several species are common to Cuba and to Puerto Rico. Attention to the papers written by Aguayo is urged for those interested in the fresh-water shells of Puerto Rico.

## KEY TO THE FRESH-WATER SPECIES

1 *a.* Bivalve; minute (length, 3 mm.); surface relatively smooth; yellow or white; beaks high and thrust forward ..... *Pisidium* sp. (Pl. IX, Fig. 7)
  *b.* Univalve ..... 2
2 *a.* Helicoid (i.e., high-spire) ..... 3
  *b.* Planorboid (i.e., flat spire) ..... 6
  *c.* Patelloid (i.e., cap shape) ..... 11
3 *a.* Sinistral or left coiled; shiny; length, 5–7 mm. *Physa cubensis* (Pl. VIII, Fig. 11)
  *b.* Dextral or right coiled; length, 8–10 mm. ..... 4
4 *a.* Large; without an operculum ..... 5
  *b.* Small (length, 3–5 mm.); with an operculum; aperture about one-third the length of the shell; smooth or with spines on a shouldered whorl. *Potamopyrgus coronatus* (Pl. IX, Fig. 11)
5 *a.* Relatively thick; length of aperture about one-half the length of shell; whorls shouldered ..... *Lymnaea cubensis* (Pl. VIII, Fig. 9)
  *b.* Thin and fragile (*Succinea*-like); length of aperture about two-thirds the length of shell; whorls not shouldered ..... *Lymnaea columella* (Pl. VIII, Fig. 10)
6 *a.* Large (diameter, 12–35 mm.) or medium size (diameter, 7–8 mm.); aperture noticeably expanded ..... 7
  *b.* Small (diameter, 4–5 mm.); aperture not expanded into a flare; armature of lamellae often deep within aperture ..... 9
  *c.* Minute (diameter, 2 mm.; height, 1 mm.); tightly coiled with final whorl appearing to engulf previous whorls; depressed on both upper and lower side. *Drepanotrema anatinum* (Pl. IX, Fig. 8)
7 *a.* Biconcave; whorls smooth and shiny; shouldered at center of whorl or peripherally ..... 8

*b.* Flattened dorsally, deeply depressed ventrally; whorls not smooth and polished but with prominent growth striae; shouldered both above and below with center or peripheral part of whorl flattened ..... *Helisoma caribaeum* (Pl. IX, Fig. 1)

8 *a.* Large (diameter, 12–35 mm.); with fine spiral striae. *Australorbis glabratus* (Pl. IX, Fig. 5)

*b.* Smaller (diameter, 7–8 mm.); without spiral striae; growth lines very fine. *Helisoma tervcrianum* (Pl. IX, Fig. 2)

9 *a.* Diameter, about 5 mm.; without spiral striae ..... 10

*b.* Diameter, about 3 mm.; only 1.0 mm. high; with spiral striae and hence formerly called "*circumlineatus*" ..... *Tropicorbis decipiens* (Pl. IX, Fig. 6)

10 *a.* Gray green; 2 mm. high ..... *Tropicorbis riisei* (Pl. IX, Fig. 3)

*b.* White; compressed, 1.5 mm. high ..... *Tropicorbis albicans* (Pl. IX, Fig. 4)

11 *a.* Large (length, 5–6 mm.); brownish; apex prominent and thrust forward to the left; with prominent radial striae ..... *Uncancylus concentricus* (Pl. IX, Fig. 9)

*b.* Small (length, 2–3 mm.); light straw color; apex only slightly twisted to the left; without prominent radial striae ..... *Ferrissia beaui* (Pl. IX, Fig. 10)

## FAMILY LYMNAEIDAE

### *Lymnaea cubensis* Pfeiffer

(Pl. VIII, Fig. 9)

*Limnaea cubensis* Pfeiffer, *Wiegmann's Archiv f. Naturg.*, I (1839): 354.

*Limnaea cubensis* Pfeiffer, Crosse, *Journ. de conchyl.*, 40 (1892): 35.

*Limnaea cubensis* Pfeiffer, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 369.

*Lymnaea* (*Nasonia*) *cubensis* Pfeiffer, Aguayo, *Mem. soc. cubana hist. nat.*, 12 (1938): 274.

*Lymnaea cubensis* is among the most common of the fresh-water snails in Puerto Rico. It was taken from the following streams: Guaynabo River, near La Muda; ditch west of Rio Cibuco, three kilometers north of Vega Baja; Riachuelo, at kilometer 10 between Cidra and Comerio; small stream north of Guajataca Forestry Station, north of Utuado; Bayamon River, two kilometers east of Bayamon; and a small silted stream about five kilometers southwest of Vega Baja. These locality data establish the species as inhabiting vegetative and quiet pools in streams of various size. This snail can withstand a wide range of habitat conditions, from heavily silted streams without vegetation to those virtually choked with plant life. It is often on the wet marginal zone along the shore of a pool or stream. C. G. Aguayo (1938*b*: 274–75) reported *L. cubensis* as common in Cuba, where it has been identified as the intermediate host of *Fasciola hepatica,* the sheep liver fluke.

### *Lymnaea* (*Pseudosuccinea*) *columella* Say

(Pl. VIII, Fig. 10)

*Lymnaea columella* Say, *Journ. Phil. Acad.*, 1 (1817): 14.

*Pseudosuccinea columella* (Say), F. C. Baker, *Freshwater Mollusca of Wisconsin,* Pt. I (1928): 272–76, Pl. X, Figs. 9–12, 20.

The history of this snail in Puerto Rico appears to be somewhat obscure. It does not seem to have been recorded by earlier workers, and hence there is a suggestion that it may have been introduced into the island in some unknown way. *L. columella* was fairly common in San Anton Creek, about six kilometers east of Rio Piedras; it was also abundant in small streams in the neighborhood of the university campus. Whether or not it is widely distributed throughout the island is not well established, but it did not reappear in any of the collections taken beyond the vicinity of San Juan. No records for this species are available in the Museum of Zoology, University of Michigan, from any of the Greater Antilles, although there are a number of localities established for it in Florida. Two named varieties are on record from Nicaragua and Uruguay. Aguayo (1938*b*: 275) reported *Lymnaea* (*Pseudosuccinea*) *francisca* Poey from several localities in Cuba, where it was reported as early as 1858 by Poey.

### *Australorbis glabratus* (Say)

(Pl. IX, Fig. 5)

*Planorbis glabratus* Say, *Journ. Acad. Nat. Sci. Phila.*, I, 10 (1818): 280.
*Planorbis guadaloupensis* Sowerby, *Genera of Recent and Fossil Shells*, IV, No. 2 (1821): no pagination, Pl. II (pls. not numbered), Fig. 2.
*Planorbis refulgens* Dunker, *Proc. Zoöl. Soc. London*, 1853, p. 54.
*Australorbis glabratus* (Say) F. C. Baker, *The Molluscan Family Planorbidae*, 1945, p. 93.

This is one of the largest fresh-water snails in Puerto Rico. It has received considerably more attention than any of the other mollusks of the island, because Faust and Hoffman (1934) have definitely established that it is the intermediate host for the disease commonly known as bilharziasis. Their work has shown that the snail inhabits the sugar-growing regions around the entire coast of the island and goes into the interior through the broad valleys of the larger rivers. Some of the basic facts established by them emphasize that these snails thrive among aquatic vegetation and show some preference for life among the roots of water hyacinth. The animals are most successful in alkaline waters (pH 7.2 to 7.8). The largest colonies are usually in pools of quiet water such as occur along streams or as are artificially created through irrigation projects. Drying or severe fluctuations in the water level, which may be brought about by irrigation operations, are unfavorable to the existence of these snails.

Some life-history information has been gathered, but Hoffman was of the opinion that much more biological information was necessary before adequate public health measures could be devised to eliminate infected snail colonies throughout the island. Prior to his death, Hoffman and Mrs. Diaz-Collazo were engaged in laboratory studies of this snail. As few similar attempts to comprehend the biology of such an intermediate host

have been made, they were seriously handicapped in this pioneering venture. Such studies are of paramount importance, and a continuance of the work is strongly urged.

In the course of the recent collecting in Puerto Rico, the following stations were established: Pond at kilometer 102, west of Camuy; pools in small stream east of campus at Rio Piedras; pools in Rio Grande de Arecibo at Jayuya; and pools of Rio Grande de Arecibo about two kilometers below Utuado. There is considerable variation in the size of specimens from various localities. The limited series observed seem to indicate that there was a dwarfing of these snails in the headwaters of rivers as indicated by the larger size of specimens in the colonies from Utuado as compared to stunted forms taken farther upstream at Jayuya.

F. C. Baker (1945: 512) figured *Australorbis blauneri* (Germain) from the island of Vieque and (1945: 514) *A. antiguensis* (Sowerby) from near Quebradillas, Puerto Rico.

## *Helisoma caribaeum* (D'Orbigny)

(Pl. IX, Fig. 1)

*Planorbis caribaeus* D'Orbigny, "Mollusques," *Histoire . . . naturelle de l'île de Cuba*, I (1842): 193, Pl. XIII, Figs. 17, 19.

*Planorbis tumidus* Pfeiffer, *Wiegmann's Archiv f. Naturg.*, I (1839): 354.

*Helisoma caribaeum* (D'Orbigny), F. C. Baker, *The Molluscan Family Planorbidae*, 1945, p. 149.

In earlier publications this species is listed as *Planorbis tumidus*, but Pilsbry (1934: 44) considered *tumidus* a synonym of *caribaeum*. As compared with *A. glabratus*, *H. caribaeum* is a relatively rare species in Puerto Rico. There are less than a half dozen records for it during the past century. Blauner found it at Humacao; Gundlach at Aguadilla and Quebradillas. Córdova collected it with *A. glabratus* in pools of a small stream just east of the campus at Rio Piedras.

Hoffman discovered a colony of *H. caribaeum* during the fall of 1942 in a pond at Muñoz Rivera Park at San Juan. He exposed these snails to miracidia of *Schistosoma mansoni* with negative results. In a communication regarding this matter he wrote:

> The peculiar thing is that the Muñoz Rivera Park forms appear to be entirely refractory to *Schistosoma mansoni* infection. Recently, I exposed one to a large number of *S. mansoni* miracidia, probably over 50, a huge infection, certainly enough to destroy a snail long before infection matures.

This experiment emphasizes that although in size and general appearance *H. caribaeum* is somewhat similar to *A. glabratus*, it behaved as did *H. lentum* of southeastern United States (Faust and Hoffman, 1934: 26) in that it would not serve as the intermediate host of *S. mansoni*.

### *Helisoma terverianum* (D'Orbigny)

(Pl. IX, Fig. 2)

*Planorbis terverianus* D'Orbigny, "Mollusques," *in* Sagra, *Histoire . . . naturelle de l'île de Cuba,* I (1853): 194–95, Fig. 20, 23.

Previously, this species does not appear to have been reported from Puerto Rico. William A. Hoffman collected a good series at "Fajardo." The specimens shown to me by Hoffman were identified by Pilsbry. A set of specimens from this same lot are in the Bryant Walker collection of the Museum of Zoology. Apparently, *H. terverianum* is rare in Puerto Rico. If F. C. Baker (1945) was familiar with this species there is no indication of it in his recent study of the Planorbidae.

### *Tropicorbis riisei* (Dunker)

(Pl. IX, Fig. 3)

*Planorbis riisei* Dunker and Clessin, Martini and Chemnitz, *Systematisches Conchylien Cabinet,* 1886, p. 110, Pl. 17, Fig. 7.

*Planorbis riisei* Dunker, Crosse, *Journ. de conchyl.,* 40 (1892): 36.

*Planorbis riisei* Dunker, Dall and Simpson, "The Mollusca of Porto Rico," 1900, p. 370.

*Tropicorbis riisei* (Dunker) F. C. Baker, *The Molluscan Family Planorbidae,* 1945, p. 85.

Crosse (1892: 36) listed *Planorbis riisei* among Puerto Rican forms with some degree of uncertainty. Three lots were collected on the island recently: in San Anton Creek, six kilometers east of Rio Piedras; in small streams west of Guajataca Forestry Station, north of Utuado; and in Manati River, four kilometers south of Manati. The specimens fit the description and figures given in the *Conchylien Cabinet* and are tentatively referred to this species. The recent publication of *The Molluscan Family Planorbidae* by the late F. C. Baker clarifies the status of this species and gives anatomical details of specimens belonging to this species collected at Lares by the late William Hoffman.

### *Tropicorbis albicans* (Pfeiffer)

(Pl. IX, Fig. 4)

*Planorbis albicans* Pfeiffer, *Wiegmann's Archiv f. Naturg.,* I (1839): 354.

*Planorbis (Planorbula) albicans* Pfeiffer, Crosse, *Journ. de conchyl.,* 40 (1892): 38.

*Planorbula albicans* Pfeiffer, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 370.

*Tropicorbis albicans* (Pfeiffer), F. C. Baker, *The Molluscan Family Planorbidae,* 1945, p. 85.

This relatively small species with its shiny, white shell was found to be rare by Blauner in eastern Puerto Rico (Aguas Claras, Ceiba, and Luquillo). Two lots were recently taken somewhat farther west at Rio de la Plata near Comerio and at San Anton Creek, about four kilometers east of Rio Piedras. Both lots have specimens with the characteristic armature of teeth within

the aperture, but there is a striking difference in the size of specimens from each series; those from the region of Comerio are about twice as large as those from San Anton Creek.

### *Tropicorbis decipiens* (C. B. Adams)

(Pl. IX, Fig. 6)

*Planorbis decipiens* C. B. Adams, *Contributions to Conchology,* 3 (1849): 43.
*Planorbis circumlineatus* Shuttleworth, "Diagnosen . . . ," 1854, p. 96.
*Tropicorbis decipiens* (C. B. Adams), F. C. Baker, *The Molluscan Family Planorbidae,* 1945, p. 85.

*T. decipiens* is most common in ditches with an abundance of aquatic vegetation and along small grass-lined creeks. Its distribution pattern throughout the island is not well established. Blauner collected it near Humacao. More recently, it was taken from the following localities: a roadside ditch near Dorado northeast of Vega Baja, a pond along road 2 at kilometer 102 west of Camuy, a wet pasture at Martin Peña, a ditch at the north end of the Biology Building in Rio Piedras, and a creek near the Home Economics Building in Rio Piedras. As implied in Shuttleworth's specific name, the small raised ridges that run parallel to the spiral whorls are a ready aid in identifying this species.

### *Drepanotrema anatinum* (D'Orbigny)

(Pl. IX, Fig. 8)

*Planorbis anatinus* D'Orbigny, *Mag. de zool.,* V (1835): 28.
*Planorbis haldemani* C. B. Adams, *Contributions to Conchology,* 1849, p. 43.
*Drepanotrema anatinum* D'Orbigny, C. G. Aguayo, *Nautilus,* 1933, p. 65.
*Drepanotrema anatinum* (D'Orbigny), F. C. Baker, *The Molluscan Family Planorbidae,* 1945, p. 118.

The rarest of the planorbid snails in Puerto Rico appears to be this minute *Drepanotrema.* Only a single station was established for it—a small stream just north of the Guajataca Forestry Station, northwest of Utuado. Blauner found it at three stations in eastern Puerto Rico (Humacao, Luquillo, and Rio Blanco). F. C. Baker (1941: 96–97) described a new species, *Drepanotrema hoffmani,* which is considerably larger and has closer affinities to *Drepanotrema lucidum,* collected by Blauner in eastern Puerto Rico, but this has not been seen recently farther west. More thorough collecting will undoubtedly considerably extend the range of all the species in this group. Aguayo (1933: 64–68) gave a very informative discussion on the synonymy and distribution of this species. The type locality, as interpreted by Aguayo, is given in the following translation from D'Orbigny (1835: 351):

We have encountered this species in the stomach of ducks which we killed on the islands of the Rio Paraná itself, a little below the city of La Bajada, capital of the

province of Entre Rios. We have searched for it in the same places; and, after much trouble, have found it in the lakes on the middle of these islands, among the aquatic plants. It seems to be rare there.

### *Drepanotrema hoffmani* F. C. Baker

*Drepanotrema hoffmani* F. C. Baker, *Nautilus,* 54 (1941): 96–97, Pl. 8.
*Drepanotrema hoffmani* F. C. Baker, *The Molluscan Family Planorbidae,* 1945, p. 118.

In addition to the description of this species as cited above, F. C. Baker has given (1945: 392) some figures of the shell based on specimens collected by William Hoffman at Isabela.

The following Planorbidae have been recorded from Puerto Rico. They have not been taken recently, and they are listed for the sake of including as many of the available records as possible.

### *Planorbis schrammi* Crosse

Crosse, *Journ. de conchyl.,* 12 (1864): 153, Pl. 7, Fig. 2.

### *Planorbis lucidus* Pfeiffer

Pfeiffer, *Wiegmann's Archiv f. Naturg.,* I (1839): 354.

### *Planorbis macnabianus* C. B. Adams

Adams, *Contributions to Conchology,* 1849, p. 43.

## FAMILY PHYSIDAE

### *Physa cubensis* Pfeiffer

(Pl. VIII, Fig. 11)

*Physa cubensis* Pfeiffer, *Wiegmann's Archiv f. Naturg.,* I (1839): 354.
*Physa sowerbyana* D'Orbigny, "Mollusques," *Histoire . . . naturelle de l'île de Cuba,* I (1842): 190, Pl. X, Figs. 11, 13.
*Physa (Physella) cubensis* Pfeiffer, Aguayo, *Mem. soc. cubana hist. nat.,* 12 (1938): 266.

In a paper dealing with the Physidae of the West Indies, W. J. Clench (1936: 339) has placed the form hitherto known as *Physa sowerbyana* D'Orbigny in the synonymy under *P. cubensis.* This species is one of the most common fresh-water snails in Puerto Rico. Blauner collected it at Humacao, Luquillo, and San Juan; Dall and Simpson reported it from the Rio Caguitas, at Caguas. To these localities the following may be added: San Anton Creek, six kilometers east of Rio Piedras; small stream at kilometer 5 on road 30, northwest of Vega Baja; creek west of Guajataca Forestry Station, north of Utuado; creek north of Guajataca Forestry Station, north of Utuado; Riachuello, kilometer 10 on road 5 between Cidra and Comerio; Guaynabo River, near La Muda, southwest of Rio Piedras;

ponded stream, two kilometers northeast of Aguas Buenas; tributary to Rio de la Plata, one kilometer east of Naranjita; creek near Home Economics Building, Rio Piedras; Manati River, four kilometers south of Manati; pond along road 2 at kilometer 102, west of Camuy.

As suggested by Clench, colonies of this snail are variable, depending somewhat on the ecological conditions to which they are subjected. Aguayo (1938*b*: 266–67) stated that *P. cubensis* is present in practically all of the streams and ponds of Cuba, where it is a variable species. He also mentioned that Perez Vigueras and Moreno have shown that *P. cubensis* serves as intermediate host for the liver fluke, *Fasciola hepatica*.

FAMILY ANCYLIDAE

### *Ferrissia beaui* (Bourguignat)

(Pl. IX, Fig. 10)

*Ancylus beaui* Bourguignat, *Journ. de conchyl.*, 4 (1853): 176.
*Ancylus beaui* Bourguignat, Crosse, *Journ. de conchyl.*, 40 (1892): 38.
*Ancylus beaui* Bourguignat, Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 371.

*Ferrissia beaui* is relatively scarce in Puerto Rico. Blauner found it near Luquillo, where it occurred on wood in pools. Three stations were established for it recently: on dead leaves in a small stream about three kilometers west of Ponce; on twigs and decaying leaves in a creek north of Guajataca Forestry Station, north of Utuado; and in pools of a small tributary to the Rio de la Plata, about one kilometer east of Naranjito. Walker (1923: 13) called attention to the faint radial sculpture shown under magnification, although Bourguignat in his description stated that the shell was smooth. Most specimens in a series from the above localities were smooth; an occasional specimen had faint radial striations.

### *Uncancylus concentricus* (D'Orbigny)

(Pl. IX, Fig. 9)

*Ancylus concentricus* D'Orbigny, *Mag. de zoöl.*, 5 (1835): 24.

As compared with *Ferrissia beaui*, this species is relatively common in Puerto Rico. It has a rather sturdy shell with prominent radial ridges. Specimens were collected from the following stations: Manati River, about four kilometers north of Manati; small stream, three kilometers west of Ponce; small creek on road 30, southwest of Vega Baja; Guaynabo River, near La Muda, southwest of Rio Piedras; San Anton Creek, six kilometers east of Rio Piedras; tributary to Rio de la Plata, one kilometer east of Naranjito.

It is usually found on dead leaves, twigs, stones, and similar objects in creeks and rivers.

Some explanation regarding the relation of D'Orbigny's *Ancylus concentricus* to *Uncancylus* may be helpful to those who do not have access to the literature. *Uncancylus* was described by Pilsbry (1913) as a subgenus of *Ancylus*. Walker (1920) considerably extended the range of species in this group. He obviously followed Pilsbry's revision. In the references listed above it is evident that Walker intended to give *Uncancylus* generic rank, which revision is also confirmed by seven lots in the Bryant Walker collection available for study in the Museum of Zoology, University of Michigan.

The following ancylid has been recorded for Puerto Rico. It has not been taken recently, and it is listed for the sake of including as many of the available records as possible.

### *Ancylus obscurus* Haldeman

Haldeman, *Monograph*, 1844, p. 9, Pl. 1, Fig. 5.

FAMILY AMNICOLIDAE

(Pl. IX, Figs. 11*a*, *b*)

### *Potamopyrgus coronatus* (Pfeiffer)

*Paludina coronata* Pfeiffer, *Wiegmann's Archiv. f. Naturg.*, I (1839): 253.
*Potamopyrgus coronatus* (Pfeiffer), Dall and Simpson, "The Mollusca of Porto Rico," 1901, p. 434.

Because of the variability of this species a large number of names have been given to it. It is a relatively common species in Puerto Rico, although most of the records available seem to limit it to the northern and eastern parts of the island. Blauner's localities include Humacao, Luquillo, Aguas Claras, and Ceiba. Gundlach found it at Aguadilla. Three stations may be added to this series: a small splash pool at Humacao Playa, Guaynabo River, near La Muda, and San Anton Creek, six kilometers east of Rio Piedras.

In the three lots mentioned spined individuals are most common in the lot from the splash pool near the sea, whereas the other lots, which were well upstream in both rivers, had relatively few specimens with the coronate development of spines. The possible causative factors for presence or absence of spines have been a matter of interest. H. A. Pilsbry (1896–99: 570) found no evidence for connecting the development of sculpture with an increase in alkalinity. W. H. Dall (1896: 408–9) stated that mollusks show a progressive increase in sculpture as the alkalinity of the water increases. C. Goodrich (1934) reviewed the literature and suggested that his own studies clearly indicate definite trends in sculptural patterns. A. E. Boycott (1929: 230) studied the inheritance of spines in *Hydrobia jenkinsi* and concluded that they were not inherited, but that there was evidence that the spinous condition was correlated with what he termed "bad" conditions.

Warwick (1944: 799), working with *P. jenkinsi* and continuing along the lines initiated by Robson and Boycott, has indicated that there are some interesting inter-relations in the case of these animals as they are influenced both by genetics and ecology. He has indicated something of this in the following statement:

> From the above experiments, it appears that *P. jenkinsi* exists as both keeled and smooth genotypes. Further, since brackish water *per se* does not induce a keel, it seems that the environmental factor responsible for the appearance of the keel is Algal. Moreover, this agency needs only to act in early life to induce a keel for the rest of the life of the snail. The Alga acts partly in a quantitative manner to produce keels of strengths varying from a scarcely perceptible ridge to fully aculeate form.

This matter is being investigated. In an area such as Puerto Rico, where *P. coronatus* inhabits both brackish and fresh waters, there should be opportunities to solve this problem experimentally.

### BIVALVES

### FAMILY SPHAERIIDAE

### *Pisidium* sp.

(Pl. IX, Fig. 7)

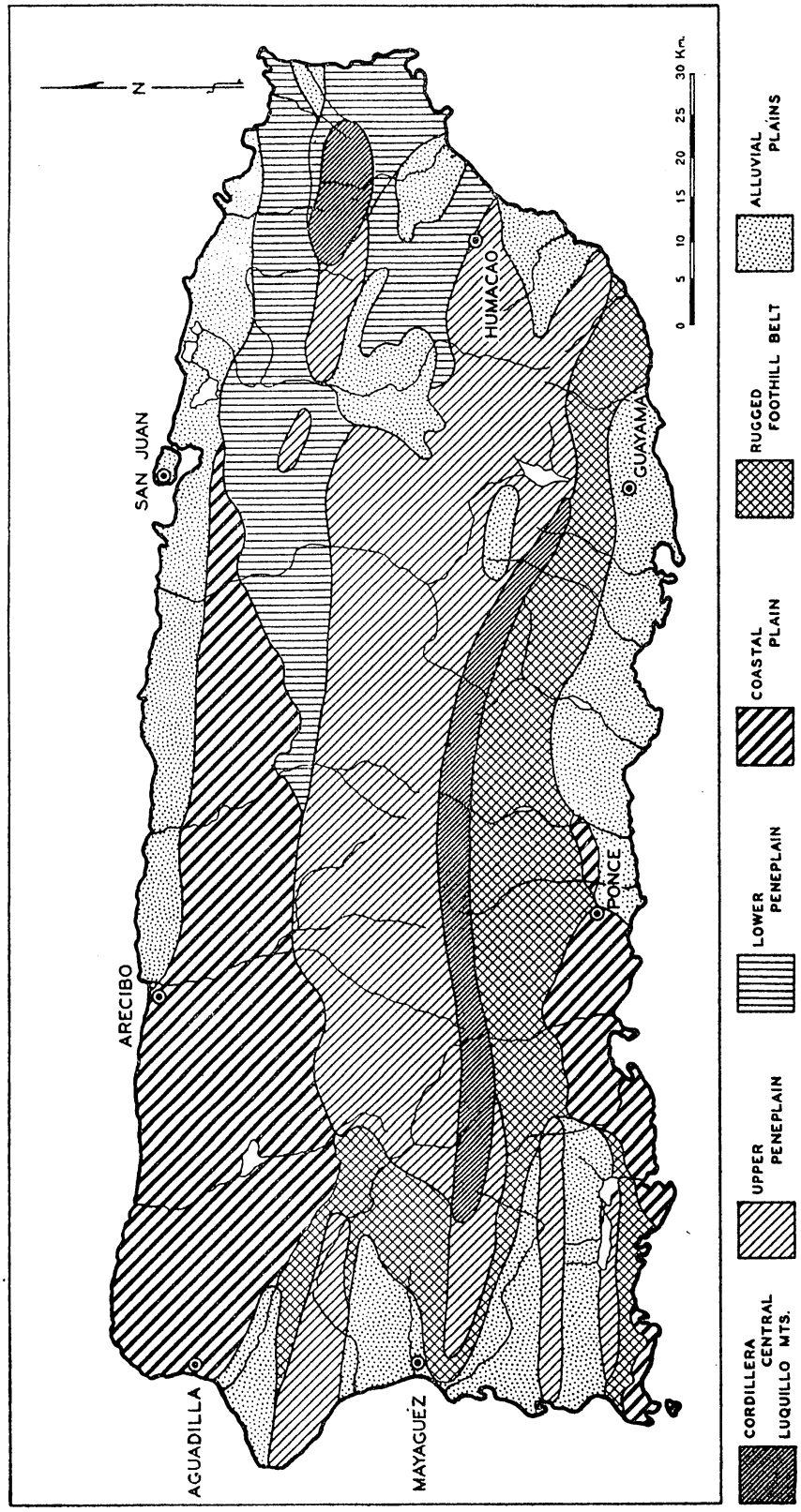
Two lots were taken, one series from Guaynabo River, near La Muda, southwest of Rio Piedras, and another from a small stream west of Guajataca Forestry Station, north of Utuado. A comparison with specimens in the collection of the Museum of Zoology indicates that these Puerto Rican sphaeriids are closely related to *Pisidium abditum* and *P. consanguineum.* In view of the uncertain taxonomic status of many of the species in this genus it is perhaps better not to assign these specimens to a specific category until more information is available about this group in the West Indies.

## PHYSIOGRAPHIC FEATURES

In simplest terms, two basic topographic features can be recognized in Puerto Rico: the central mountains which may be termed the "Old Land," and the coast border, or coastal plains. R. J. Hill (1899) presented a rather graphic picture of the general aspect of these zones in the following statement:

> The mountains constitute the major surface of the island, approximately nine-tenths of the whole. The other features collectively make an irregular and lower lying belt around the coastal margin comparable to the narrow rim of a high-crowned alpine hat. In fact, the whole island is practically an elongated sierra, made up mostly of volcanic rock, surrounded by a narrow collar or dado of limestone hills, formerly marginal marine incrustations which have been elevated.

A. K. Lobeck (1922) has given a somewhat more detailed account of the physiographic provinces. These important features are reproduced from Lobeck's original map (Map 64). Although there is a possibility that




MAP 64. Physiographic Provinces in Puerto Rico as given by Lobeck (1922).

significant correlations exist between certain land snails and the regions delimited by Lobeck, the material at hand permits a correlation mainly with two of these geomorphic features: (1) the mountain or Old Land region and (2) the limestone of the coastal plains. For practical purposes it will be convenient to consider this fauna distributionally under these broad headings, with the realization that these large areas are sufficiently complex ecologically to restrict several species to smaller regions within them. More exact inter-relations could perhaps be the subject of future investigations.

The mountain region is generally agreed to have been a mass of basic igneous rock. The original matrix has weathered rapidly under the influence of a warm, humid climate to form a rather characteristic deep, arenaceous, clay soil. As Hill (1899) has aptly stated:

> This mountain soil is one of the most marked features of the island, and to it are largely due many of its agricultural and forestal conditions. Were it less tenaceous and sticky (and language can hardly convey an idea of the unctuousness of this stickiness, which is especially disagreeable as a road material), the mountain slopes of Porto Rico would now be washed and dreary wastes of barren rock.

Wherever rainfall is high these soils have become badly leached and are almost free of calcium, magnesium, and phosphorus. Timber, banana trees, and coffee are grown on many of these soils. Small pockets of limestone occur in this interior mountain range. Some of these, upon weathering within humid and semihumid districts, produce soils which yield good tobacco crops. There is a noticeable increase in the number of land shells in such limestone pockets, but as yet the relationship can only be indicated in a general way. The species inhabiting the mountain province, however, are usually the widely scattered forms, and there is a decided absence there of certain species characteristic of the coastal plain.

From the records available, comparatively few species are restricted to the central mountains. Those that seem especially worthy of mention are the following: *Mcleania darlingtoni* of the Maricao and Adjuntas regions; *Polydontes luquillensis* and *Megalomastoma verruculosum,* both restricted to the Luquillo Mountains; such forms as *Nenia tridens, Obeliscus terebraster,* and *Polydontes acutangula* appear to find their optimum state in this elevated zone, although they are not restricted to it. Several species, such as *Polydontes lima* (form *maricao*), *Megalomastoma croceum* (form *hjalmarsoni*), and *Cepolis dermatina* (form *angulifera*), all are modified or stunted in the mountain region. A correlation, as has been pointed out previously, exists showing that such dwarfing becomes more pronounced in certain species with an increase in altitude. As has been suggested, the factors responsible are likely to involve a stunting in the more lime-leached upland soils; a condition which might be shown, eventually, to vary somewhat with the abundance of rainfall in these higher altitudes. This condition is similar to that

recorded by Amos Brown (1911), who found a stunting of species of *Pleurodonte* in Jamaica. As he suggested, however, the reduction in shell size in that region was certainly not due to a lack of lime but rather to the porous nature of the limestone on which the snails lived. This rock permitted such a rapid loss of moisture that the snails suffered from "periodic dryness and malnutrition during the season when forms in the lower ground are growing continuously under optimum conditions of moisture and food supply. . . ."

The coastal plains have several distinctive physiographic features (Map 64). Two of these are apparently most significantly considered in terms of their influence on the mollusk fauna. Structurally, they can be grouped as (1) the intensively cultivated alluvial regions, and (2) the somewhat unmolested rock outcrops, represented by the *cerros* of the southwest and the *pepino* or haystack hills of the north coast.

If the extensive coastal and river flood plains ever had a characteristic native flora and fauna, their composition will perhaps never be fully known. At present, this level and slightly rolling country is covered largely with sugar cane, and a few favorable sections are used for growing some fruits and vegetables. A relatively small number of mollusks inhabit such greatly disturbed regions. In ditches along the roads of cultivated sections, if there is a small amount of cover provided by decaying leaves or other detritus, one is apt to find only such generally prevalent species as *Subulina octona* and *Alcadia striata.* If some trees, such as the introduced "flamboyant" are present, colonies of *Polydontes lima* and *Pleurodonte marginella* may occur on the trunks and larger branches. A somewhat more varied assemblage of snails is apt to be present only when outcropping limestone has prevented the cultivation or continued disturbance of an isolated pocket.

The *cerros* are rows of parallel east-west, limestone hills in the southwestern part of the island. Fertile valleys occur between the crests of these hogback structures. Such *cerros* are especially common between Guanica and Ponce on the east, and from east of San German to near the town of Cabo Rojo in the west. Topographically, these have become complex by virtue of former folding and dissection. Some have the appearance of dissected cuestas. H. B. Baker referred to these elongated east-west trending hills as Los Peñones, and he properly indicated that they are separated from the coastal limestone, which is almost continuous from west of Ponce to Cabo Rojo (the cape), by a broad and arid valley. Hill (1899) described these hills:

> Composed entirely of chalky or loose-textured glaring white limestone of a very porous character, often chalky, which was deposited around the margin of the mountainous island mass when it was submerged about 600 feet lower than it stands at present. These are largely of Pleistocene age, although some of the lower strata may be as old as the Oligocene. Their surface is often covered by the peculiar efflorescent calcareous precipitate known in Mexico as tepetate which forms a shallow subsoil or pan.

The mollusks collected from the limestone hills of the southwestern region are for the most part the same ones that inhabit the same type of knoll along the northern coastal plain. There is, then, a faunal, as well as a structural, similarity in this region. H. B. Baker (1941*c*) found several species in this area not previously observed elsewhere in Puerto Rico; *Stoastomops puertoricana* and *Stoastomops boriqueni* in "Los Peñones," *Licina graminosa* and *Microceramus guanicanus* in the coastal limestone, and *Chondropoma swifti* and *Cerion* apparently also limited to the southern coastal limestone. Several of the species common to both the northern haystack knolls and the *cerros* of the southwest appear to have a discontinuous range, with a break in their distribution prominent in the region east of Mayaguez. More careful re-examination of the fauna and the physiographical features of this intermediate area would perhaps be helpful in appreciating the historical value of the discontinuous pattern observed.

The haystack or pepino ("cucumber") hills of the northern coastal plain are among the most striking topographic features of the island. They are particularly prominent on the plain between Bayamon and Arecibo (Map 64, "Coastal Plain"). As seen from a distance the knolls may appear singly; more often they occur in west-southwest trending chains, with a saw-tooth or cockscomb profile caused by their irregular and jagged peaks. These rugged and honey-combed limestone masses are of little value to the peasants who till the land around them. In their neglected state with a natural vegetative cover, they serve as islands of refuge for a rich and varied mollusk fauna. O. D. von Engeln (1942), R. C. Roberts (1942), and others have referred to this region as typifying a karst topography. In the cycle of reduction through solution and underground drainage, these ancient, uplifted coral reefs have experienced many varieties of uneven collapse, causing, according to von Engeln (1942), "the formation of residual conical summits, resembling haystacks, called *pepino hills* . . . in Puerto Rico, mogotes in the Isle of Pines (Carlson, 1942)."

Physiographers seem to concur that there is a similarity between a *mogote* as that term is used in the Isle of Pines (perhaps also in Cuba)[3] and the haystack knoll of Puerto Rico. With the similarity of these geomorphic features in mind some effort was made to determine whether the pepino hills possessed anything comparable to the great extent of endemism generally known to be present on the *mogotes* of Cuba. Gundlach, as previously indicated, came to Puerto Rico from Cuba expecting to find "different species that change within short distances." As suggested by him (1883), this is not the situation in Puerto Rico. Although relatively many species inhabit

[3] The late Thomas Barbour in *A Naturalist in Cuba* (Boston: Little Brown and Company, 1945, pp. 288–91) has given an informative discussion of the limestone structures of Cuba.

this karst region, within short distances there are no sudden specific changes such as are present in similar areas of Cuba. Some of the species among those more or less restricted to the haystack knolls and *cerros* of the coastal plains of Puerto Rico are:

*Lucidella umbonata*
*Lucidella vinosa*
*Fadyenia portoricensis*
*Licina decussata*
*Licina aguadillensis*
*Chondropoma riisei*
*Pupisoma minus*
*Pupisoma dioscoricola*
*Bothriopupa tenuidens*
*Gastrocopta servilis*
*Gastrocopta pellucida*
*Opeas pumilum*
*Lamellaxis gracilis*
*Lamellaxis micra*
*Obeliscus swiftianus*
*Drymaeus virgulatus*
*Drymaeus liliaceus*
*Brachypodella portoricensis*
*Brachypodella riisei*
*Brachypodella pallida*
*Pseudopineria viequensis*
*Macroceramus microdon*

The distribution of the species in the preceding list suggests that there is some correlation between certain geomorphic features and the presence or absence of a few genera and several species. Although accurate information is lacking for some phases of this work, the field is one that offers significant results. With future studies in mind, it would seem worth while if, in terms of the geological history of the region, an analysis could be made of the relation of geographically restricted species and the possible causal factors for such limitations. Principles derived from such studies could perhaps be applied to advantage in evaluating connections that formerly existed between parts of the Greater Antilles. Crosse (1892: 46) had something of this sort in mind when he emphasized that the presence of *Fadyenia portoricensis* was a very interesting distributional fact, suggesting a relation between the fauna of Puerto Rico and that of Jamaica, which appears to be the center of development for this genus. H. B. Baker is of the opinion that Crosse placed too much zoogeographical importance on such a small, easily carried snail, particularly since these small forms often are widely distributed.

There are about twice or more as many species inhabiting the coastal limestone formations as are present in the central mountainous, volcanic zone. This contrast can be shown by comparing two collections from a typical station in each zone: Station 31, wet north slope of main mountain range, two kilometers south of Cayey.

*Megalomastoma croceum*
*Chondropoma blauneri*
*Alcadia striata*
*Alcadia alta*
*Polydontes lima*
*Pleurodonte carocolla*
*Austroselenites concolor*
*Obeliscus terebraster*
*Obeliscus dominicensis hasta*
*Subulina octona*
*Laevaricella glabra*
*Varicella portoricensis*
*Varicella terebraeformis*
*Nenia tridens*

Station 71, wooded haystack knoll, about five kilometers west of Vega Baja.

*Megalomastoma croceum*
*Chondropoma riisei*
*Helicina phasianella*
*Alcadia striata*
*Lucidella vinosa*
*Lucidella umbonata*
*Fadyenia portoricensis*
*Cepolis musicola*
*Polydontes lima*
*Pleurodonte marginella*
*Zachrysia auricoma havanensis*
*Thysanophora plagioptycha*
*Lacteoluna subaquila*
*Lacteoluna selenina*
*Bulimulus exilis*
*Brachypodella portoricensis*
*Brachypodella riisei*
*Brachypodella pallida*
*Pseudopineria viequensis*
*Macroceramus microdon*
*Obeliscus terebraster*
*Obeliscus swiftianus*
*Obeliscus dominicensis hasta*
*Subulina octona*
*Lamellaxis monodon opalescens*
*Lamellaxis unilamellata*
*Lamellaxis micra margaritaceus*
*Opeas pumilum*
*Varicella portoricensis*
*Varicella terebraeformis*
*Guppya gundlachi*
*Striatura meridionalis*
*Succinea hyalina*
*Gastrocopta servilis*
*Gastrocopta pellucida*
*Pupisoma dioscoricola*

These lists indicate that there is perhaps some correlation between geological formations and the number of species within them. H. von Martens[4] (1890–1901) has reported a similar observation in Guatemala, where more species inhabited the limestone regions of "north Guatemala" than were in the metamorphic area of "central Guatemala." Hesse (1937: 417) stated that there are also several statistical observations indicating such a correlation among the vertebrates. Satisfactory explanations are given for none of these groups of animals. Some malacologists believe that the greater abundance of species in limestone areas is a direct result of the chemical composition of the soil, a condition which might be stated as an obvious necessity for animals such as shell-building mollusks. Other competent zoologists question whether it is entirely a matter of soil chemistry. The question is raised, as stated by H. von Martens (1890–1901), whether it is not also largely due to the physical condition of limestone, for the honeycombed aspect offers an ideal habitat for land shells. There is, then, a need for experimental evidence to ascertain which combination of factors is of importance in delimiting the ecological demands of the species inhabiting these major geological zones.

Many physical, as well as faunal, differences exist between Puerto Rico and the British Isles. Yet, the general conclusions arrived at by Boycott (1934) in his monumental study of the ecology of the land mollusks of Britain may well serve to suggest the factors that are often basic in the environment of land shells. Boycott (1934: 34) concluded:

[4] Guppy (1887) and Bollinger (1909) have also called attention to an apparent chemical effect of substrata on snails, depending on the nature of the subsoil they inhabit.

Our land Mollusca do not form specific associations with one another or with other animals or plants. Competition is therefore an unimportant factor. Their occurrences within their geographical ranges are determined by the conditions of the environment, the most important factors being moisture and lime. We may distinguish groups which affect wet places, dry places and human settlements. The rest, about half the species, live in ill-defined 'woodland' habitats whose suitability varies in proportion to the shelter and lime they provide. In the alternative classification, we have one calcifuge species, about twenty calcicoles, about eighteen which prefer lime and forty-five which are indifferent.

Not only is there a reduction from the relatively numerous species in the calcareous coastal plains to the fewer forms inhabiting the igneous mountainous mass, but species such as *Polydontes lima* and *Megalomastoma croceum,* and perhaps others, that occur throughout both regions are apt, as previously shown, to become stunted in the mountains. The correlation was made with altitude. Actually, the conditions responsible may have been a reduction in available lime, which, in turn, may also have been correlated with differences in elevation. More important, perhaps, is the uneven distribution of rainfall. This variation, caused by the prevailing northeast trade winds, is one of the most striking features of the island. There is an unusually high rainfall in the El Yunque region. The northward slope of the Cordillera Central seems to become progressively drier westward along the north coast. The south shore is arid, and in the southwest conditions are practically those of a desert. Analytical studies of the influence of these variations in moisture as they influence the biology of mollusks would probably be a fertile field for study. Similar correlations in reduction of shell size with altitude have been made by D'Alte Welch (1938: 145, 151; 1942: 201–3) for species of *Achatinella* in Hawaii, and by Knipper (1939: 455–62) for helicid species of southeastern Europe.

C. Oldham (1934: 131–38) has shown experimentally that snails supplied with lime build heavier and slightly larger shells than those not supplied with this ingredient. Oldham concluded:

Whilst one must recognize the possibility of races of snails having an inherent capacity for assimilating lime and constructing shells heavier than the normal and, conversely, of races having, with the same opportunity, an inherent incapacity for constructing shells of normal weight, the evidence adduced suggests that in most cases, at any rate, after due allowance has been made for age differences, the weight of the shell is the measure of the snail's opportunity to obtain lime in a suitable form. The question arises of the propriety of bestowing varietal names because of some quality, obviously due to the effect of its environment upon the individual snail, which in the view of nomenclators and systematists shall rank equally with names bestowed on account of some inborn and heritable quality. To call a snail *crassa* because it has enjoyed and taken advantage of the opportunity to assimilate lime, or *tenuis* because it has been denied that opportunity, is, it seems to me, as illogical and likely to serve as little purpose as to assign the varietal names *depilata* to a tonsured monk, *picta* to a tattooed man, *roseolabiata* to a girl addicted to rouge, or *curta* to a horse with a docked tail.

## ZOOGEOGRAPHIC RELATIONS

Prior to the Mesozoic, the Antillean area seems, from the fragmentary bits of evidence available, to have been a low, flat crest or shield. Conditions are assumed to have been quiescent until sometime between the Jurassic and Cretaceous, when mountain-forming changes, including volcanic activity, took place. In the course of these events the Greater Antilles were formed. Something of the nature of these changes is given by Meyerhoff (1933) who stated: "If the waters of the Atlantic and the Caribbean could be drained, the Greater Antillean islands would appear as one of the most imposing mountain elements on the earth." The four main islands, according to him, are conceived of as "huge earth blocks elongated from east to west," bounded by great block faults which give the highest mountain tops a maximum relief of about 38,000 feet above the ocean botton.

During a considerable part of the Mesozoic, particularly in the Triassic and Jurassic, there appears to have been relatively little geologic activity in Puerto Rico. But, in the Cretaceous, especially during Upper Cretaceous time, great volcanic activity ensued. Some subsidence occurred with this explosive action, giving rise to a few sedimentary formations among the rocks referred to this era. At the close of the Cretaceous, there was a folding of the partly consolidated rock, due to pressure applied from the south or Carribean side. The crumpled igneous crust fractured in many places and permitted lava to flow out over the pre-Mesozoic beds. It is clear, however, that the high mountain region of the interior of Puerto Rico is composed primarily of Cretaceous components. Also, it should be emphasized that there is some evidence that these mountains were connected formerly with those of Santo Domingo. According to Meyerhoff (1933: 56): "Deformed strata appear part way across in Desecheo Island, but the rocks and structures of eastern Santo Domingo have not been studied, and at present it is impossible to correlate them with those of Puerto Rico." It is with some assurance that he later added: "During the early part of the Tertiary period the Antillean mountains of Puerto Rico stretched eastward to the Virgin Island, southeast to Saint Croix, and westward into Santo Domingo."

While the structure of the mountain core of Puerto Rico is mainly a result of Cretaceous events, the establishment of the prominent coastal plains is attributed largely to Tertiary time. Two great masses of Tertiary limestone, the San Sebastian formation in the northwest and the Juana Diaz shales in the south-central region, are believed to have been formed by embayments which covered those areas during middle Tertiary time (Meyerhoff, 1933: Fig. 10). Meyerhoff (1933) stated that in this same period: "Apparently the dissected Antillean mountains still stretched unbroken across

Mona Passage, and faunal migration went on in an extremely limited way around the attenuated eastern ends of the folds." During the remainder of the Oligocene the prominent limestone known as the Lares formation was laid down, intergrading with the San Sebastian shales underneath.

Limestone deposition continued into the middle Miocene, forming some five distinct formations having an accumulated thickness of three thousand to four thousand feet. Meyerhoff (1933: 71) has mapped the configuration of the island during this period of coastal limestone formation. Later in the Miocene the island was elevated. Erosion followed, resulting in the formation of those features now present in Puerto Rico. It was in the course of this degradation that the prominent upper or St. John peneplain (Map 64) was formed. The relatively high altitude of this peneplain at present is attributed to two upward movements of the earth. The first elevation occurred at the end of the Miocene, when the land was raised eight hundred feet. Renewed stream activity eventually excavated the deep gorges in which streams now flow through this peneplain. A second period of erosion is assigned to the Pliocene, when the rivers which had deeply entrenched themselves after the first elevation, began, according to Meyerhoff (1933), "to broaden their valleys and cut divides." He added: "That task did not take long, for the materials are soluble and they are situated near the sea where the stream volumes are largest." Thus, a new peneplain was formed which is referred to as the lower peneplain (Map 64).

In Quaternary time, as is partly revealed by studies of the relation of the Caguana peneplain in Santo Domingo and Saint Croix to the same plain in Puerto Rico, there were tectonic changes that split Puerto Rico from the Virgin Islands to the east and Santo Domingo to the west. The separation is believed by Meyerhoff to have been as recent as the close of the glacial epoch. This relationship is significant, particularly as it might have an important bearing on zoogeographic considerations of these island areas. The presence of *Nenia* in both Puerto Rico and Santo Domingo lends weight to the suggestion that these islands were formerly connected.

Theories and hypotheses regarding the former arrangement of the Antillean land masses are quite diverse. H. von Ihering (1931) conjectured land bridges, which presumably spanned the Atlantic and Pacific oceans. His discussions are quite hypothetical and somewhat abstruse, and there are some difficulties in applying his conjectures to present knowledge of the phylogeny and distribution of some groups of mollusks. Perhaps, when more is known, there will be better opportunity for evaluating the conditions he postulates. In any event, he deserves consideration for attempting to correlate the information available in the fields of geology and zoogeography. Bailey Willis (1932) used "isthmian links" to connect continents. An im-

portant consideration favoring isthmuses rather than continental land bridges, such as Gondwanaland conceived by Suess and expounded by Arldt and von Ihering, is contained in the basic concept: "Once a continent, always a continent. Once a basin, always a basin." This statement is supported by certain physical conditions which imply that continents are made up of lighter materials which float on or are supported by heavier masses constituting the ocean basins. Connecting continents by isthmian links not only appears reasonable but also eliminates serious difficulties which arise when bodies of continental proportions are used to establish seemingly necessary connections.

Something of the isthmian concept was suggested by Vaughn (1918). Charles Schuchert (1935) accepted Vaughn's interpretations as given in his fundamental work on the Cenozoic history of the West Indies and Central America. Among the structural provinces established by Vaughn in that region is one which includes "Honduras and its continuation to and including Jamaica, southern Haiti, Puerto Rico, the Virgin Islands, and St. Croix." Schuchert adopted this arrangement in principle, but amplified it somewhat in the following statement:

> Region 4. (Chapters 29–35) embraces, first, the Greater Antilles. These islands are the eastern continuation of the Central American protaxis, one branch of which passes from Honduras and northern Nicaragua across the submerged Honduran plateau to Jamaica and into southern Haiti-San Domingo; while the ranges of Guatemala and British Honduras appear to pass through the Caymans and continue through eastern Cuba across northern Haiti-San Domingo. Hispaniola, in fact, is where the Antillean protaxis also meets the necessary ranges from Cuba, and thence, together they extend eastward as a single range, passing through Puerto Rico and the Virgin Islands.

Several investigators have subjected special groups of plants and animals inhabiting the Greater Antilles to analyses in order to determine whether the distributional and phylogenetic relationships of the biological elements give information bearing on connections that may have formerly existed between the various islands and the mainland regions as they are now known. Schuchert (1935) has gathered together the results of some of these studies, and he has incorporated the findings of biologists in a chapter of his Antillean work entitled *Biogeography*. It is unnecessary to make special mention of the contributions made by the authors whose work Schuchert reviews. Of the fourteen separate studies considered, thirteen emphasize that the Antillean fauna has Central American affinities. In fact, there is essential agreement among geologists and biologists concerning the general relationships, although many knotty problems remain to be solved.

The only dissenting voice among the fourteen previously mentioned seems to be that of E. R. Dunn (1932), who re-examined the generic value of the colubrid snakes of the Greater Antilles. He came to the conclusion

that when the endemism in local areas is considered, there were relatively few migrations from the mainland. However, his cautious statement admits at least that there were "a few migrations." One might well raise the question as to where the few groups that are common to the mainland and the islands originated. Pilsbry (1911) in his discussion of the nonmarine mollusca of Patagonia stated: " . . . In most of the families only one or a few genera have invaded South America out of a large number in the parental lands." There is evidence here, although in another group of animals, that even though but a few genera invade a region, former land connection may be indicated.

G. G. Simpson (1940) has made an interesting contribution to this problem in an article entitled "Mammals and Land Bridges." He cited the West Indies as a classic example of what he termed a "sweepstake route." He stated (1940: 154):

> In the West Indies the Pleistocene land mammals included only peculiar rodents, insectivores, and ground sloths, without any of the ungulates, carnivores, and other groups abundant on all adjacent continental areas. This fauna, too, is inexplicable as a result of normal filtering on a land bridge such as here envisaged. I am aware that some excellent authorities do maintain that these faunas arrived over bridges (see general summary in Schuchert, 1935), but I can not feel that they have clearly seen or considered the conditions that could give such a result. (Fig. 6.)

The unusual wealth of mollusk species in the West Indies was emphasized in some of the earliest publications dealing with this region. There was also a pioneering appreciation by Charles B. Adams of the highly characteristic nature of the zoological provinces existing on these islands. Thomas Bland (1861) emphasized this in the following statement: "Seeing, moreover, the greater number of both genera and species, absolutely and proportionately, in the islands under consideration, it may not unreasonably be suggested that the insular stamp has rather been impressed on the fauna of the adjacent continents, than the reverse." Two important divisions, based on the distribution of the shells, were made within the West Indies. Puerto Rico, Vieques, and islands as far east as Anguilla were grouped with the Greater Antillean sphere to form one great province in which there was a preponderance of operculate land shells; the chain of the Lesser Antilles, beginning with St. Christopher and Antigua and going south toward Venezuela, was considered as another province in which there is a scarcity of operculates and in which the fauna shows more affinities with that of South America. Somewhat later, H. Crosse (1892) gave a number of faunal comparisons of species in Puerto Rico with those in the remaining islands of the Greater Antilles. He concluded that there is a remarkable similarity in the faunal groups, a condition which was in accord with the best geological information then available. More recently, Schuchert (1935: 90) has divided

Antillia into the following four land-shell provinces: "(a) Cuba (with the Bahamas, and southern Florida as an appendage); (b) Jamaica; (c) Haiti, Puerto Rico, and the Virgin Islands, with the northern, limestone Caribbees (Guadeloupe to Grenada). Trinidad and Tobago are related to South America."

It is of interest to note that since the time of Adams, Bland, and Crosse, there have been some general accounts of the mollusks of parts of Central America. Formerly, emphasis was placed on the relation and possible connections that existed between these insular mollusks and those of the North American and South American mainland. North America was vaguely defined, and the comparisons mainly confined to the state of Florida. With an increase in knowledge of the fauna of Central America, the distribution of related forms in the Greater Antilles takes on an added significance, particularly if it can be determined what the inter-relationships of these groups in neighboring regions are and how they may have come about as interpreted in the light of more complete geological information.

Considered in terms of the previous work in Central America, I was impressed with the striking similarity that exists between the species present there and those common to Puerto Rico. Aguayo (1938*b*: 221–25) also emphasized that the fresh-water forms in Cuba have Central American affinities. These affinities, as well as the differences, are emphasized by comparing species lists available for the following regions: Guatemala (von Martens, 1890–1901; Hinkley, 1920; Goodrich and van der Schalie, 1937; van der Schalie, 1940), Panama (Pilsbry, 1926), Santo Domingo (Pilsbry, 1933), and Puerto Rico (Crosse, 1892). These major areas follow somewhat the Honduras–Jamaica–Santo Domingo protaxis established by Vaughn and subscribed to by Schuchert. It becomes obvious that many genera among the land shells have bridged the gap now existing between these islands and the the mainland. Whether the faunal similarities emphasized here are significant, and whether they are rendered less significant by the fact that many of the closest relations are among small species, is as yet an open question. It may be noted, however, that within the area separation has been sufficiently long to permit the development of several groups which are characteristic for each zone as delimited. Pilsbry (1930) stated that he was of the opinion that there has not been a connection between Central America and Cuba or Jamaica later than the Paleocene or Eocene; a deduction he made largely because of the divergence in development of some groups. Schuchert (1935: 108), however, believed that Antillia and Central America " were again united in early Oligocene time and once more during the Miocene-early Pliocene."

Although Schmidt (1943) considers that too many land bridges have been constructed to account for distribution of various animals, he seems

to imply, if I interpret his statement correctly, that there is a close resemblance between the reptiles of the West Indies and those of Central America. He stated (1943: 250):

> The families of reptiles here considered are listed in the accompanying table. It will be seen that the West Indian fauna includes 13 families, of which only three belong to the Tertiary group; but the remaining ten families may be thought of as derived from Central America rather than a 'South American Element' in the West Indies.

Whether he would account for this similarity by granting a possible "land bridge" from Central America to the West Indies is unknown. P. J. Darlington, Jr. (1938: 287), admitted:

> . . . the conformation of land in the past, with the narrowest water gap on the Central American side, and the directions of hurricanes have favored immigration of animals into the Greater Antilles chiefly from Central America, even if there have never been complete land connections. The relationships of the fauna with Central America, therefore, do not necessarily indicate a Central American land bridge, nor can geologists say for sure whether or not such a bridge has ever existed.

It is generally known that certain of the genera common to Central America and the Greater Antilles have probably managed to invade widely separated regions by fortuitous means. Species of *Subulina* and *Opeas* are known to have been introduced accidentally into distant regions. Such groups naturally have very little value in studies which attempt to show former land connections. In order to attain some accuracy in solving zoogeographical problems, it becomes imperative for zoologists to define carefully the ecological demands of many genera in an effort eventually to use fully the information which may prove or disprove some of the theories previously advanced. The necessity for such analysis is evident from the following statement taken from Schuchert (1935: 83):

> Another group of animals to which much biogeographic significance is attached is the land snails. These shelled invertebrates can live for many days immersed in sea water, and operculate forms can seal themselves in their shells and so retain life for years. This latter capability was accidentally discovered when shells that had been glued on museum tablets and placed on exhibition for several years were soaked in water to remove them from the tablets, and the animals were found to be still alive. By means of logs, cane stems and rafts of plant debris, some snails can be widely distributed . . . .

This statement is somewhat typical of a kind of broad, sweeping statement that often leads workers unfamiliar with the significance of applying accurately determined details when shells are used in tracing former land connections to jump to wild conclusions. The truth of Schuchert's statement is not questioned, but it is important that a differentiation be made between groups that behave thus and those that do not. Also, even within the limits of the species which show such remarkable survival, some detailed information regarding their distribution in nature is necessary before it is possible to adhere to claims that even these snails are carried from island to

island by "waif dispersal." At present, the list of genera and species of the Antilles and Central America is hardly complete, not to mention that little or nothing is known about many of the significant ecological and distributional aspects so necessary for sound reasoning in zoogeographical problems. If, in the future, a firm foundation can be built by carefully recording pertinent biological information about some of the key groups, it is quite possible that the problems that pertain to the establishment of some of the former land connections will be solved. Geologists are aware of the contributions which can be made in this field by biologists. Schuchert (1935: 109–10) stated:

> The greatest weakness in the land connections here discussed is in the area of the Nicaraguan-Rosalind-Pedro banks, which make the continental connections via Jamaica between the Greater Antilles and Central America. This is the crux of our disagreements. These connections must, after all, be adjusted among the biogeographers, and mainly on the basis of the present land life since but little of the ancient life will ever be recovered.

The problem of dispersal of animals is often decidedly complex. Some investigators have indicated that birds might serve as agents in the distribution of snails, especially for fresh-water pulmonates. In the West Indies, evidence has been given by De la Torre, Clench (1938), and others working with mollusks, that hurricanes may have been instrumental in distributing a number of species. P. J. Darlington (1936) has given a very informative discussion of the effects of hurricanes in dispersing animals with particular reference to transporting animals from Central America to the Greater Antilles. C. Montague Cooke (1926: 2280), who has made extensive studies of the land shells of many Pacific Islands, stated:

> The distribution of smaller species (most of which are less than five millimeters in length or diameter) is partly due to the Polynesians and partly to natural causes, of which the most important is probably hurricanes. Practically all species of snails that inhabit forests or the higher portions of an island are peculiar to a single island, and with very few exceptions they never get beyond a single group of islands.

In this connection, it is of interest to note that in Puerto Rico several of the minute land shells which are previously listed (page 114) as confined more or less to the haystack knolls of the coastal plains, behave in a manner strikingly similar to that of some of the small forms studied by Cooke.

From the evidence available, there seems, as Darlington (1938) has ably indicated, to be a decided lack of evidence to prove conclusively whether the Antillean fauna crossed from Central America to the West Indies across water gaps or over land bridges. The whole matter of distribution and origin of this fauna appears as yet most inconclusive. Perhaps, when sufficient detailed information is available from the several fields that can contribute to the solution of this problem, a clearer concept can be attained of the origin of these insular animals.

## REFERENCES

ADAMS, C. B.

1849–52 Contributions to Conchology. New York: Baillière. Pp. 1–258.

AGUAYO, C. G.

1933 On the Synonymy and Distribution of *Planorbis anatinus* Orbigny. Nautilus, 47: 64–68.

1938*a* *Pseudopineria,* Un Nuevo genero de moluscos. Mem. soc. cubana hist. nat., 12: 71–73.

1938*b* Los Moluscos fluviatiles cubanos. Parte I. Generalidades. Parte II. Sistematica. *Ibid.,* 12: 203–42, 253–76.

1944 Leptinaria lamellata y otros moluscos introducidos en Cuba. Rev. soc. mal., "Carlos de la Torre," 2: 51–58.

BAKER, F. C.

1941 A New Species of *Drepanotrema* and Some Preoccupied Planorbid Names. Nautilus, 54: 96–97.

1945 The Molluscan Family Planorbidae, Part I. Classification and General Morphology. Urbana: Univ. Illinois Press. Pp. i-xxxvi, 1–530.

BAKER, H. B.

1924 Land and Freshwater Molluscs of the Dutch Leeward Islands. Occ. Papers Mus. Zool. Univ. Mich., 152: 1–158, Pls. 1–21.

1926 Anatomical Notes on American Helicinidae. Proc. Acad. Nat. Sci. Phila., 78: 35–56, Pls. 5–8.

1930*a* The North American Retinellae. *Ibid.,* 82: 193–219.

1930*b* The Land Shell Genus *Haplotrema.* *Ibid.,* pp. 405–25, Pls. 33–35.

1933 A Checklist of Nearctic Zonitidae. Occ. Papers Mus. Zool. Univ. Mich., 269: 1–14.

1934 Jamaican Land Snails. Nautilus, 48: 13–14.

1940*a* New Names for Puerto Rican Snails. *Varicella* (*Laevaricella*) *playa,* New Species. *Cepolis* (*Plagioptycha*) *boriquenae,* New Species. *Ibid.,* 53: 107.

1940*b* New Subgenera of Antillean Helicinidae. *Hjalmarsona* and *Striatemoda.* *Ibid.,* 54: 70–71.

1940*c* Some Antillean Sagdidae and Polygyridae. *Ibid.,* pp. 54–62.

1941*a* Some Haplotrematidae. *Ibid.,* pp. 130–36.

1941*b* Puerto Rican Oleacinidae. *Ibid.,* 55: 24–30.

1941*c* New Puerto Rican Shells. Notulae Nat., 88: 1–6.

1943*a* Some Antillean Helicidae. Nautilus, 56: 81–91.

1943*b* *Megalomastoma croceum* (Gmelin). *Ibid.,* pp. 106–7.

BARTSCH, PAUL

1930 Explorations for Mollusks in the West Indies. Explorations and Field-Work of the Smithsonian Institution in 1929, pp. 99–112.

1942 The Cyclophorid Operculate Land Mollusks of America. *In* Carlos de la Torre, Paul Bartsch, and Joseph P. E. Morrison. U. S. Nat. Mus. Bull., 181: i–iv, 1–306, 42 pls.

1943 Puerto Rican *Megalomastoma.* Nautilus, 57: 30.

BEQUAERT, J., and WILLIAM J. CLENCH

1936 A Second Contribution to the Molluscan Fauna of Yucatan. Carnegie Inst. Wash. Publ., 457: 61–75.

1939 *Mcleania,* a New Genus of Land Mollusks from Puerto Rico. Mem. soc. cubana de hist. nat., 13: 283–84, Pl. 36.

BLAND, THOMAS

1861 On the Geographical Distribution of the Genera and Species of Land Shells of the West Indian Islands, with a Catalogue of the Species of Each Island. New York: Baillière Bros. Pp. 9–35.

1866 Remarks on the Origin and Distribution of the Operculated Land Snails Which Inhabit the Continent of America and the West Indies. Amer. Journ. Conch., 2: 54–58.

1875 Notes on Certain Terrestrial Mollusks, with Descriptions of New Species. Ann. Lyc. Nat. Hist. N. Y., 11: 72–87.

BOETTGER, OSKAR

1887 Vier neue westindische Pneumonopomen. Jahrb. deutschen malak. Gesellsch., 14: 101–2.

1909 Neue *Nenia;* Bestimmungsschlüssel und Literaturnachweise für die bis jetzt bekannten *Nenia-* Arten (Clausiliidae). Nachr. deutschen malak. Gesellsch., 41: 162–83.

BOLLINGER, GOTTFRIED

1909 Zur Gastropodenfauna von Basel und Umgebung. Inaug. Diss., Univ. Basel, pp. 1–214, 1 pl.

BOYCOTT, A. E.

1929 The Inheritance of Ornamentation in Var. *aculeata* of *Hydrobia jenkinsi* Smith. Proc. Malacol. Soc. London, 18: 230–34, 1 pl.

1934 The Habitats of Land Mollusca in Britain. Journ. Ecology, 22: 1–38.

BROWN, AMOS P.

1910 The Method of Progression of Some Operculates from Jamaica. Nautilus, 24: 85–90.

1911 Variation in Some Jamaican Species of Pleurodonte. Proc. Acad. Nat. Sci. Phila., 63: 117–64, Pls. 7–11.

CLENCH, WILLIAM J.

1930 Notes on Physidae with Descriptions of New Species. Occ. Papers Boston Soc. Nat. Hist., 5: 301–15.

1936 The Physidae of the West Indies. Mem. soc. cubana hist. nat., 10: 335–42, 1 pl.

1938*a* Origin of the Land and Freshwater Mollusk Fauna of the Bahamas, with a List of the Species Occurring on Cat and Little San Salvador Islands. Bull. Mus. Comp. Zool., 80: 481–541.

1938*b* Land and Freshwater Mollusks of Grand Bahama and Abaco Islands, Bahama Islands. Mem. soc. cubana hist. nat., 12: 303–33, 1 pl.

1940 Two New Land Shells from Puerto Rico and St. Croix. *Ibid.*, 14: 243–44, 1 pl.

COOKE, C. MONTAGUE, JR.

1926 Notes on Pacific Land Snails. Proc. Third Pan-Pacific Sci. Congress, Tokyo, pp. 2276–84.

CROSSE, H.

1891 Faune malacologique terrestre et fluviatile de l'île de Saint-Domingue. Journ. conchyl., 39: 69–211.

1892 Faune malacologique terrestre et fluviatile de l'île de Portorico. *Ibid.*, 40: 5–71.

DALL, WILLIAM H.

1896 Insular Landshell Faunas, Especially as Illustrated by the Data Obtained by Dr. G. Baur in the Galapagos Islands. Proc. Acad. Nat. Sci. Phila., pp. 408–9.

DALL, WILLIAM H., and C. T. SIMPSON
1901 The Mollusca of Porto Rico. U. S. Fish Comm. Bull. for 1900, 1: 351–524, Pls. 53–58.

DALY, R. A.
1934 The Changing World of the Ice Age. New Haven: Yale Univ. Press. Pp. ix–xxi, 1–271.

DARLINGTON, P. J.
1938 The Origin of the Fauna of the Great Antilles, with Discussion of Dispersal of Animals over Water and Through the Air. Quart. Rev. Biol., 13: 274–300.

DUNN, EMMET R.
1932 The Colubrid Snakes of the Greater Antilles. Copeia, pp. 89–92.

ENGELN, O. D. VON
1942 Geomorphology; Systematic and Regional. New York: Macmillan Co. Pp. 563–70.

EVERMANN, BARTON W., and M. C. MARSH
1902 The Fishes of Porto Rico. Bull. U. S. Fish Comm. for 1900, pp. 49–350.

FAUST, E. C. and W. A. HOFFMAN
1934 Life History of Manson's Blood Fluke (*Schistosoma mansoni*): Extra-mammalian Phase of the Cycle. Proc. Soc. Exp. Biol. N. Y., 31: 474–76.

FÉRUSSAC, ANDRÉ DE
1821–22 Tableaux systématiques des animaux mollusques, . . . Paris: A. Bertrand. Pp. v–vlvij.

GOODRICH, CALVIN
1934 Studies of the Gastropod Family Pleuroceridae III. Occ. Papers Mus. Zool. Univ. Mich., 300: 1–11.

GOODRICH, C., and HENRY VAN DER SCHALIE
1937 Mollusca of Peten and North Alta Vera Paz, Guatemala. Misc. Publ. Univ. Mich. Mus. Zool., 34: 1–50, 1 pl.

GUNDLACH, JUAN
1883 Apuntes para la fauna Puerto-Riqueña. Anales soc. esp. de hist. nat., 12: 441–84.

GUPPY, H. B.
1887 The Solomon Islands and Their Natives. London: Swan Sonnenschein, Lowrey and Co. Pp. 336–43.

HESSE, RICHARD
1937 Ecological Animal Geography (Edited by W. C. Allee and K. P. Schmidt). New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd. Pp. i–xiv, 1–597.

HILDEBRAND, S. F.
1935 An Annotated List of Fishes of the Fresh Waters of Puerto Rico. Copeia, pp. 49–56.

HILL, R. T.
1899 Porto Rico. Nat. Geogr. Mag., 10: 93–112.

HINKLEY, A. A.
1920 Guatemala Mollusca. Nautilus, 34: 37–55.

IHERING, H. VON
1931 Land-Bridges Across the Atlantic and Pacific Oceans During the Kainozoic Era. Quart. Journ. Geol. Soc. London, 87: 376–91.

JOUSSEAUME, F.

1900 Mollusques terrestres. *Clausilia, Rhodea,* et *Bulimus* Sud-Americanae. Bull. soc. philomath. Paris, n.s., II: 34, Pl. 1, Figs. 13–14.

KNIPPER, HELMUT

1939 Systematische, anatomische, ökologische und tiergeographische Studien an südosteuropäischen Heliciden. Archiv f. Naturg., N. F., 8: 327–517.

LAMARCK, J. B.

1815–22 Histoire naturelle des animaux sans vertèbres. Paris: Verdière.

LOBECK, A. K.

1922 Physiography of Porto Rico. Sci. Surv. Porto Rico and Virgin Islands, 1: 327–43.

MARTENS, E. VON

1877 Land- und Süsswasser-Schnecken von Puertorico. Jahrb. deutschen malak. Gesellsch., 4: 340–62.

1882 Description of Two Species of Land Shells from Porto Rico, W. I. Ann. N. Y. Acad. Sci., 2: 370–71.

1883 Diagnosen neuer Arten. Jahrb. deutschen malak. Gesellsch., 10: 81–84.

1891 Conchylien von Portorico. Nachr. deutschen malak. Gesellsch., 23: 131–33.

1890–1901 Land and freshwater mollusca. Biologia Centrali-Americana. Zoologia, 9: i–xxviii, 1–706, Pls. 1–44.

MEYERHOFF, H. A.

1933 Geology of Puerto Rico. Monographs Univ. Puerto Rico, 1: 1–306.

MORITZ, C.

1836 Notizen zur Fauna der Insel Puertorico. Archiv f. Naturg., 2: 375.

OLDHAM, C.

1934 Further Observations on the Influence of Lime on the Shells of Snails. Proc. Malacol. Soc. London, 31: 131–38.

PFEIFFER, L.

1839 Wiegmann's Archiv f. Natur., I: 351.

1875 Zur Molluskenfauna von Portorico. Malakozool. Blätt., 22: 118–19.

PILSBRY, H. A.

1889 Manual of Conchology, Second Series. Philadelphia: Acad. Nat. Sci., 5: 57–59, 122–28.

1896–99 Manual of Conchology. *Ibid.,* 12: 7, 10, 23, 224.

1901–2 Manual of Conchology. *Ibid.,* 14: 302 pp., 62 pl.

1904 Manual of Conchology. *Ibid.,* 16: vii–xxiv, 49, 109, 117.

1906 Manual of Conchology. *Ibid.,* 18: 74, 196, 198–99, 202, 268–69, 272–73, 284–96.

1907–8 Manual of Conchology. *Ibid.,* 19: 119–22.

1909–10 Manual of Conchology. *Ibid.,* 20: 2–5, 39–45.

1911 Non-Marine Mollusca of Patagonia. Rept. Princeton Univ. Exp. to Patagonia, 1896–99, 3: 513–633.

1912–14 Manual of Conchology, Second Ser., 22.

1913 Appendix: Notes on Gundlachia Pfr. Proc. Acad. Nat. Sci. Phila., 65: 671.

1916–18 Manual of Conchology. *Ibid.*, 24: 70, 76, 229.

1918–20 Manual of Conchology. *Ibid.*, 25: 86–87.

1920 Review of the *Thysanophora plagioptycha* group. Nautilus, 33: 93–96.

1920–21 Manual of Conchology. Second Ser., 26: 36–37, 40–41, 113.

1926*a* The Land Mollusks of the Republic of Panama and the Canal Zone. Proc. Acad. Nat. Sci. Phila., 78: 57–133.

1926*b* South American Land and Fresh Water Mollusks: Notes and Descriptions VI. *Ibid.*, 78: 1–15.

1927 Note on the Genus *Ceratodiscus*. Nautilus, 41: 62.

1928 Studies on West Indian Mollusks. The Genus *Zachrysia*. Proc. Acad. Nat. Sci. Phila., 80: 581–606.

1929 Studies on West Indian Mollusks, II: The Locomotion of Urocoptidae and Descriptions of New Forms. *Ibid.*, 81: 443–67.

1930 Results of the Pinchot South Sea Expedition—I. Land Mollusks of the Caribbean Islands, Grand Cayman, Swan, Old Providence and St. Andrew. *Ibid.*, 82: 221–61.

1933 Santo Domingan Land Mollusks Collected by Daniel C. Pease, 1932, and by A. A. Olsson, 1916. *Ibid.*, 85: 121–62.

1934 Review of the Planorbidae of Florida, with Notes on Other Members of the Family. *Ibid.*, 86: 29–66.

1940 Land Mollusca of North America. Acad. Nat. Sci. Phila., Monogr. No. 3, 1, Pt. 2: 981.

PILSBRY, H. A., and E. G. VANATTA

1927 *Ceratodiscus*, A Genus of Operculate Gastropoda New to Porto Rico. Proc. Acad. Nat. Sci. Phila., 79: 21–22.

REHDER, H. A.

1939 A New *Nenia* from Haiti and Some Notes on the Genus. Journ. Wash. Acad. Sci., 29: 171–73.

RICHARDS, H. G., and P. W. HUMMELINCK

1940 Land and Freshwater Mollusks from Margarita Island, Venezuela. Notulae Nat., 62: 1–16.

ROBERTS, R. C.

1942 Soil Survey of Puerto Rico. U. S. Dept. Agr., Bur. Plant Industry, Ser. 1936, No. 8: 1–503, maps.

SCHMIDT, KARL P.

1943 Corollary and Commentary for "Climate and Evolution." Amer. Midland Nat., 30: 241–53.

SCHUCHERT, CHARLES

1935 Historical Geology of the Antillean-Caribbean Region. New York: John Wiley & Sons, Inc. Pp. 1–811.

SHUTTLEWORTH, R. J.

1854 Diagnosen Neuer Mollusken, No. 6. Beiträge zur näheren Kenntnis der Land- und Süsswasser-Mollusken der Insel Portorico. Bern. Mitth., März, pp. 125–48, Juni, pp. 89–102.

SIMPSON, C. T.

1894 Distribution of the Land and Fresh-Water Mollusks of the West Indian Region, and Their Evidence with Regard to Past Changes of Land and Sea. Proc. U. S. Nat. Mus., 17: 423–50.

SIMPSON, G. G.
1940 Mammals and Land Bridges. Journ. Wash. Acad. Sci., 30: 137–63.

STAHL, A.
1882 Catalogo del gabinete zoológico del Dr. A. Stahl en Bayamon (Pto-Rico). Precedido de una clasificacion sistemática de los animales que corresponden a este fauna. Imprenta del "Boletin Mercantil," 37 Fortaleza, pp. 113–20.

STREBEL, H., and GEORG PFEFFER
1880 Beitrag zur Kenntnis der Fauna mexikanischer Land- und Süsswasser-Conchylien. Thiel 4, 112 pp., 15 Taf.

THIELE, J.
1929 Handbuch der Systematischen Weichtierkunde. Erster Teil. Jena: Gustav Fischer. 376 pp.

TORRE, CARLOS DE LA, PAUL BARTSCH, and J. P. E. MORRISON
1942 The Cyclophorid Operculate Land Mollusks of America. U. S. Nat. Mus. Bull., 181: 1–306.

TRYON, GEORGE W.
1899 Manual of Conchology. Proc. Acad. Nat. Sci. Phila., 12: 26.

VANATTA, E. G.
1911 *Planorbis bicarinatus* and *Pleurodonte angulata.* Nautilus, 24: 136–38.

VAUGHN, T. W.
1918 Geologic History of Central America and the West Indies During Cenozoic Time. Bull. Geol. Soc. Amer., 29: 615–30.

VAN DER SCHALIE, HENRY
1940 Notes on Mollusca from Alta Vera Paz, Guatemala. Occ. Papers Mus. Zool. Univ. Mich., 413: 1–11.

WAGNER, ANTON
1911 Systematisches Conchylien Cabinet. Nürnberg: Bauer & Raspe. Pp. 71, 93.

WALKER, BRYANT
1920 *Ancylus obscurus* Haldeman and Species Referred to It. Nautilus, 33: 99–103; 34: 73–76.
1921 The Relations of the Ancyline Fauna of South Africa and South America. Twenty-second Ann. Rept. Mich. Acad. Sci., p. 121.
1923 Bourguignat's American Species of *Ancylus.* Nautilus, 37: 7–16.

WARWICK, T.
1944 Inheritance of the Keel in *Potamopyrgus jenkinsi* (Smith). Nature, London, 154: 798–99.

WATSON, HUGH
1928 The Affinities of *Cecilioides* and *Ferussacia,* Illustrating Adaptive Evolution. Journ. Conchol., 18: 217–43, 2 pls.

WELCH, D'ALTE A.
1938 Distribution and Variation of *Achatinella mustelina* Mighels in the Waianae Mountains, Oahu. Bull. Bishop Mus., Honolulu, 152: 3–164.
1942 Distribution and Variation of the Hawaiian Tree Snail *Achatinella apexfulva* Dixon in the Koolau Range, Oahu. Smith. Misc. Coll., Wash., 103 (1): 1–236.

WILLIS, BAILEY
1932 Isthmian Links. Bull. Geol. Soc. Amer., 43: 875–952.

PLATES

## PLATE I

FIG. 1. *Alcadia striata* (Lamarck). *a.* Height, 7.2 mm.; width, 11.9 mm. *b.* Height, 4.7 mm.; width, 8.0 mm.

FIG. 2. *Alcadia hjalmarsoni* (Pfeiffer). Height, 4.5 mm.; width, 7.0 mm.

FIG. 3. *Alcadia alta* (Sowerby). Height, 4.3 mm.; width, 4.6 mm.

FIG. 4. *Helicina phasianella* "Sowerby" Pfeiffer. Height, 6.1 mm.; width, 8.6 mm.

FIG. 5. *Lucidella vinosa* (Shuttleworth). Height, 1.9 mm.; width, 3.7 mm. *a.* Front view. *b.* Basal view.

FIG. 6. *Lucidella umbonata* (Shuttleworth). Height, 3.4 mm.; width, 6.0 mm.

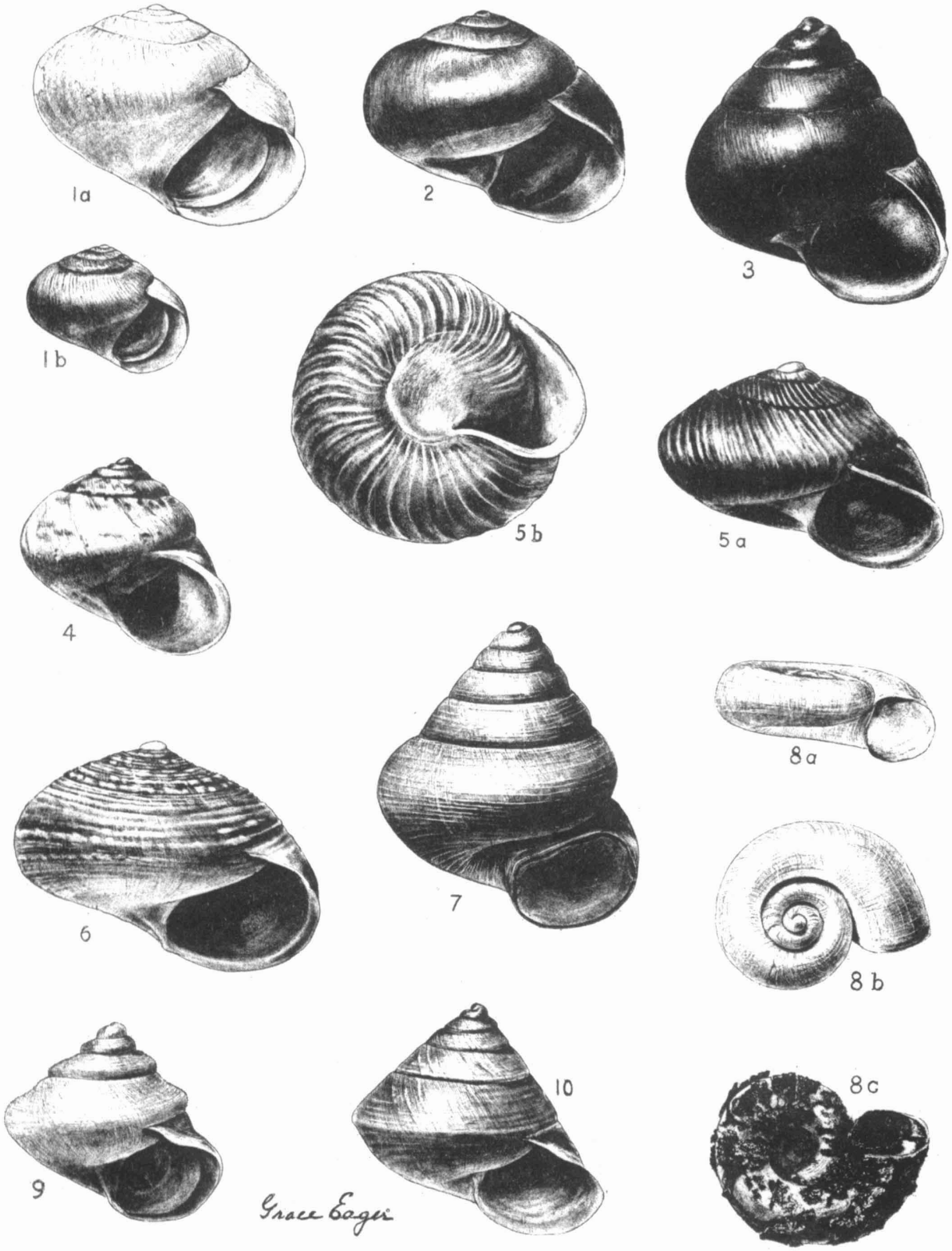
FIG. 7. *Fadyenia portoricensis* (Pfeiffer). Height, 2.2 mm.; width, 2.6 mm.

FIG. 8. *Ceratodiscus portoricanus* Pilsbry and Vanatta. Height, 1.2 mm.; width, 3.3 mm. *a.* Front view of cleaned specimen. *b.* Top view of same weathered specimen. *c.* Basal view of a fresh specimen with soil attached to shell.

FIG. 9. *Stoastomops puertoricana* H. B. Baker. Height, 2.0 mm.; width, 2.7 mm.

FIG. 10. *Stoastomops boriqueni* H. B. Baker. Height, 3.3 mm.; width, 4.4 mm.

PLATE I



## PLATE II

FIG. 1. *Megalomastoma croceum* (Gmelin). *a.* Height, 37 mm.; width, 11 mm. This specimen has the dimensions of larger forms on the coastal plain. *b.* Height, 20.5 mm.; width, 8 mm. These dimensions indicate the stunting that occurs in the uplands.

FIG. 2. *Megalomastoma verruculosum* Shuttleworth. Height, 10.2 mm.; width, 5.3 mm.

FIG. 3. *Licina decussata* (Lamarck). Female: height, 17.5 mm.; width, 8.5 mm.

FIG. 4. *Licina aguadillensis* (Pfeiffer). Male: height, 14.0 mm.; width, 6.8 mm.

FIG. 5. *Licina graminosa* H. B. Baker. Female: height, 15.2 mm.; width, 8.0 mm.

FIG. 6. *Chondropoma riisei* (Pfeiffer). Male: height, 12.4 mm.; width, 5.0 mm.

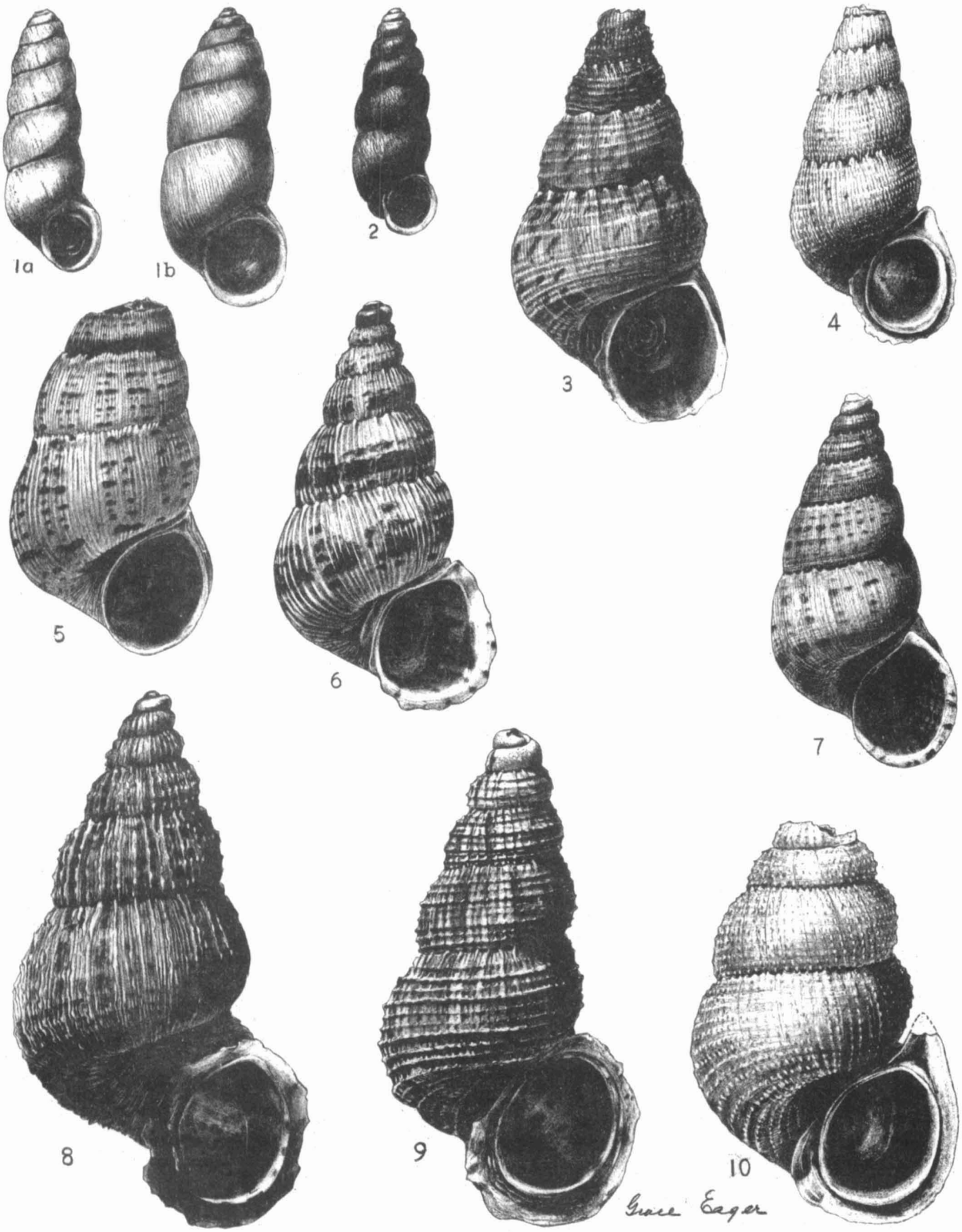
FIG. 7. *Chondropoma blauneri* (Shuttleworth). Male: height, 16.5 mm.; width, 7.0 mm.

FIG. 8. *Chondropoma conseptum* (von Martens). Male: height, 14. 0 mm.; width, 6.5 mm.

FIG. 9. *Chondropoma yunquei* H. B. Baker. Male: height, 13.0 mm.; width, 5.4 mm.

FIG. 10. *Chondropoma swifti* (Shuttleworth). Female: height, 11.0 mm.; width, 6.0 mm.

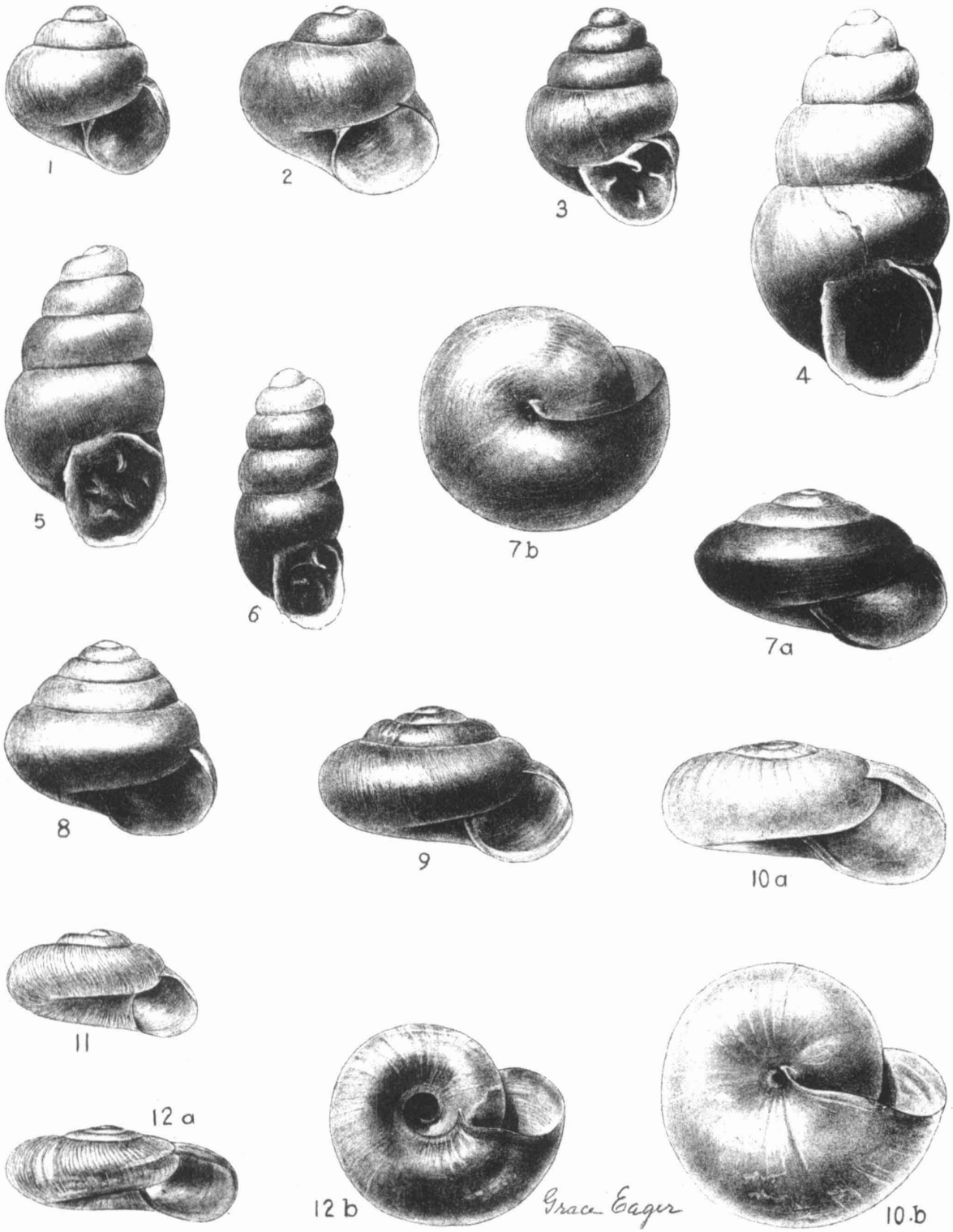
PLATE II



## PLATE III

FIG. 1. *Pupisoma minus* Pilsbry. Height, 1.3 mm.; width, 1.5 mm.
FIG. 2. *Pupisoma dioscoricola* (C. B. Adams). Height, 1.3 mm.; width, 1.5 mm.
FIG. 3. *Bothriopupa tenuidens* (C. B. Adams). Height, 1.4 mm.; width, 1.0 mm.
FIG. 4. *Pupoides nitidulus* (Pfeiffer). Height, 3.8 mm.; width, 1.8 mm.
FIG. 5. *Gastrocopta servilis* (Gould). Height, 2.0 mm.; width, 1.0 mm.
FIG. 6. *Gastrocopta pellucida* (Pfeiffer). Height, 1.6 mm.; width, 0.8 mm.
FIG. 7. *Guppya gundlachi* (Pfeiffer). Height, 1.4 mm.; width, 2.5 mm. *a.* Front view. *b.* Basal view.
FIG. 8. *Habroconus* cf *ernsti* (Jousseaume). Height, 2.5 mm.; width, 2.8 mm.
FIG. 9. *Hawaiia minuscula* (Binney). Height, 1.0 mm.; width, 1.9 mm.
FIG. 10. *Retinella insecta* (von Martens). Height, 2.2 mm.; width, 5.0 mm. *a.* Front view. *b.* Basal view.
FIG. 11. *Striatura meridionalis* (Pilsbry and Ferriss). Height, 0.5 mm.; width, 1.4 mm.
FIG. 12. *Zonitoides arboreus* (Say). (cf *Helix bryodes* Shuttleworth). Height, 1.5 mm.; width, 4.1 mm. *a.* Front view. *b.* Basal view.

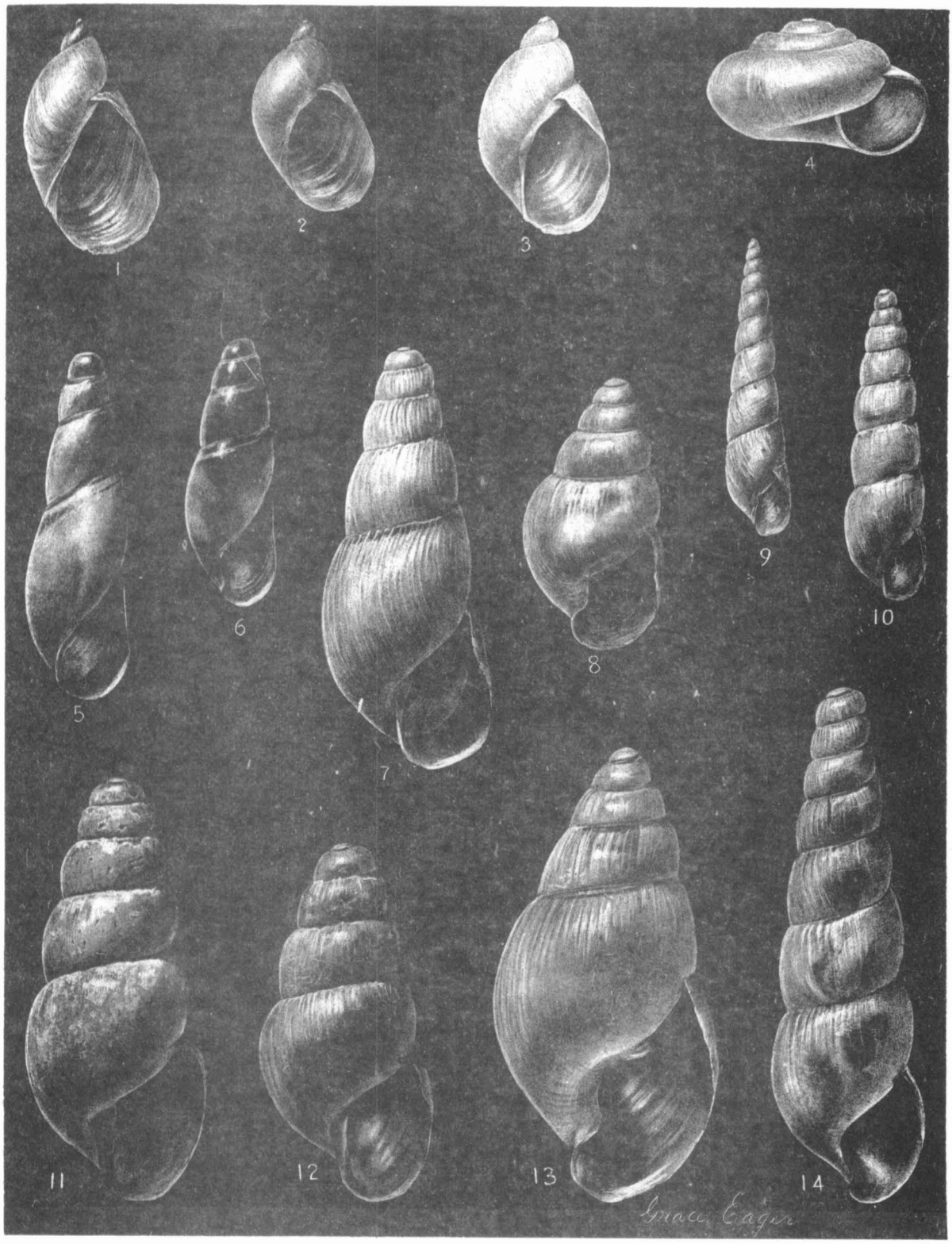
PLATE III



## PLATE IV

FIG. 1. *Succinea approximans* Shuttleworth. Height, 9.4 mm.; width, 5.5 mm.
FIG. 2. *Succinea hyalina* Shuttleworth. Height, 8.2 mm.; width, 4.6 mm.
FIG. 3. *Succinea riisei* Pfeiffer. Height, 9.9 mm.; width, 5.7 mm.
FIG. 4. *Miradiscops* sp. Height, 1.0 mm.; width, 1.7 mm.
FIG. 5. *Cecilioides gundlachi* (Pfeiffer). Height, 4.0 mm.; width, 1.1 mm.
FIG. 6. *Cecilioides consobrina* (D'Orbigny). Height, 2.0 mm.; width, 0.7 mm.
FIG. 7. *Opeas pumilum* (Pfeiffer). Height, 4.5 mm.; width, 1.7 mm.
FIG. 8. *Lamellaxis monodon opalescens* (Shuttleworth). Height, 5.0 mm.; width, 2.8 mm.
FIG. 9. *Obeliscus terebraster* (Lamarck). Height, 28.3 mm.; width, 5.5 mm.
FIG. 10. *Obeliscus swiftianus* (Pfeiffer). Height, 8.0 mm.; width, 2.3 mm.
FIG. 11. *Lamellaxis gracilis* (Hutton). Height, 5.5 mm.; width, 2.1 mm.
FIG. 12. *Lamellaxis micra margaritaceus* (Shuttleworth). Height, 4.0 mm.; width, 1.8 mm.
FIG. 13. *Lamellaxis unilamellata* (D'Orbigny). Height, 8.3 mm.; width, 4.4 mm.
FIG. 14. *Subulina octona* (Bruguière). Height, 14.0 mm.; width, 3.7 mm.

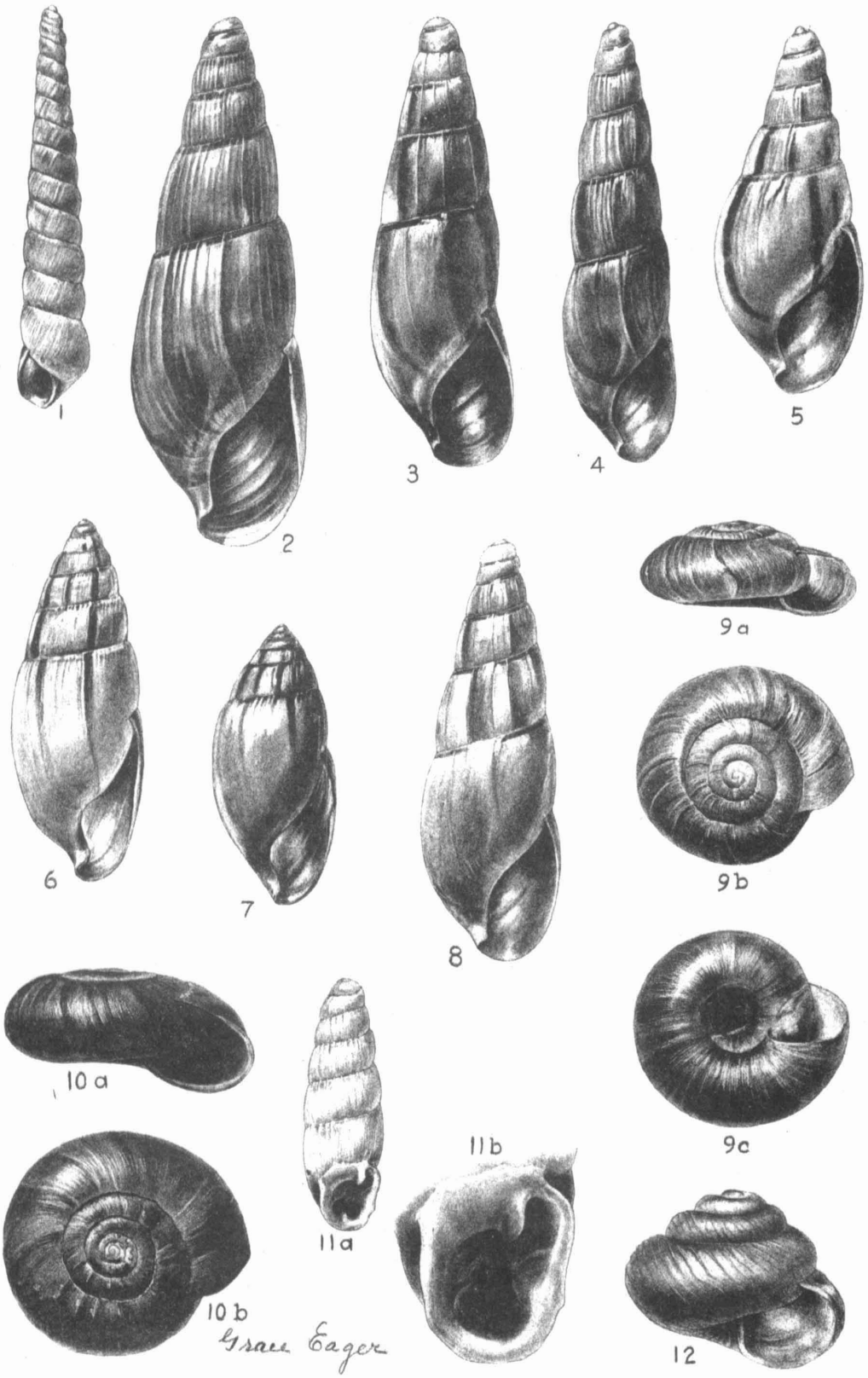
PLATE IV



## PLATE V

FIG. 1. *Obeliscus dominicensis hasta* (Pfeiffer). Height, 17.1 mm.; width, 3.0 mm.
FIG. 2. *Varicella calderoni* H. B. Baker. Height, 12.5 mm.; width, 4.2 mm.
FIG. 3. *Varicella sporadica* H. B. Baker. Height, 11.4 mm.; width, 3.5 mm.
FIG. 4. *Varicella terebraeformis* (Shuttleworth). Height, 11.5 mm.; width, 2.9 mm.
FIG. 5. *Laevaricella interrupta* (Shuttleworth). Height, 15.5 mm.; width, 6.2 mm.
FIG. 6. *Laevaricella playa* H. B. Baker. Height, 31.0 mm.; width, 11.0 mm.
FIG. 7. *Laevaricella glabra* (Pfeiffer). Height, 23.2 mm.; width, 11.0 mm.
FIG. 8. *Varicella portoricensis* (Pfeiffer). Height, 19.0 mm.; width, 6.3 mm.
FIG. 9. *Austroselenites concolor* (Férussac) H. B. Baker. Height, 7.4 mm.; width, 18.0 mm. *a.* Front view. *b.* Top view. *c.* Basal view.
FIG. 10. *Austroselenites alticola* H. B. Baker. Height, 8.7 mm.; width, 20.5 mm. *a.* Front view. *b.* Top view.
FIG. 11. *Gulella bicolor.* (Hutton). Height, 6.0 mm.; width, 2.0 mm. *a.* Front view. *b.* Enlargement of aperture.
FIG. 12. *Thysanophora plagioptycha* Shuttleworth. Height, 2.0 mm.; width, 2.5 mm.

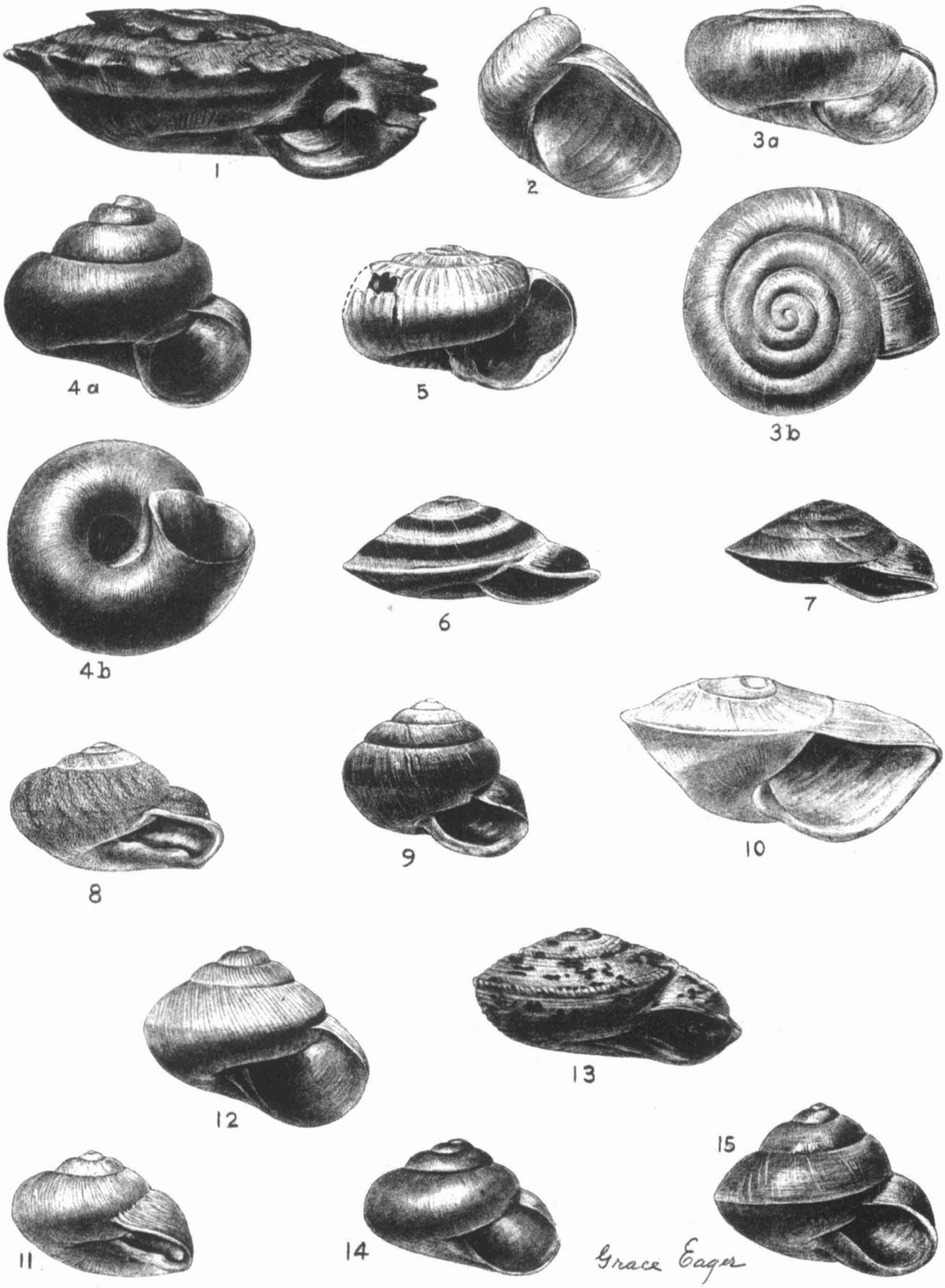
PLATE V



## PLATE VI

FIG. 1. *Moleania darlingtoni* Bequaert and Clench. Height, 3.5 mm.; width, 11.5 mm.
FIG. 2. *Platysuccinea portoricensis* (Shuttleworth). Height, 18.8 mm.; width, 14.5 mm.
FIG. 3. *Lacteoluna selenina* (Gould). Height, 2.0 mm.; width, 4.0 mm. *a.* Front view. *b.* Top view.
FIG. 4. *Microconus* cf. *wilhelmi* (Pfeiffer). Height, 1.9 mm.; width, 2.7 mm. *a.* Front view. *b.* Basal view.
FIG. 5. *Yunquea denselirata* H. B. Baker. Height, 2.3 mm.; width, 4 mm.
FIG. 6. *Pleurodonte marginella* (Gmelin). Height, 12.5 mm.; width, 32.5 mm.
FIG. 7. *Pleurodonte carocolla* (Linnaeus). Height, 23.0 mm.; width, 56.0 mm.
FIG. 8. *Polydontes lima* (Férussac). Height, 16.0 mm.; width, 25.5 mm.
FIG. 9. *Polydontes luquillensis* (Shuttleworth). Height, 25.0 mm.; width, 33.0 mm.
FIG. 10. *Polydontes acutangula* (Burrow). Height, 19.0 mm.; width, 37.5 mm.
FIG. 11. *Zachrysia auricoma havanensis* Pilsbry. Height, 17.0 mm.; width, 24.5 mm.
FIG. 12. *Cepolis musicola* (Shuttleworth). Height, 6.5 mm.; width, 6.0 mm.
FIG. 13. *Cepolis squamosa* (Férussac). Height, 7.5 mm.; width, 16.5 mm.
FIG. 14. *Cepolis boriquenae* H. B. Baker. Height, 7.8 mm.; width, 13.0 mm.
FIG. 15. *Cepolis dermatina* (Shuttleworth). Height, 9.0 mm.; width, 14.0 mm.

PLATE VI



## PLATE VII

FIG. 1. *Bulimulus exilis* (Gmelin). Height, 19.0 mm.; width, 8.5 mm. *a.* Normal form. *b.* Scalariform specimen. *c.* Normal sculpture on nepionic whorl of scalariform specimen. *d.* Basal view of same specimen.

FIG. 2. *Macroceramus microdon* (Pfeiffer). Height, 6.5 mm.; width, 2.5 mm. *a.* Normal specimen of coastal plain. *b.* Enlargement of nepionic whorl. *c.* Larger form of uplands designated as variety: *shuttleworthi.* Height, 16.5 mm.; width, 5.0 mm.

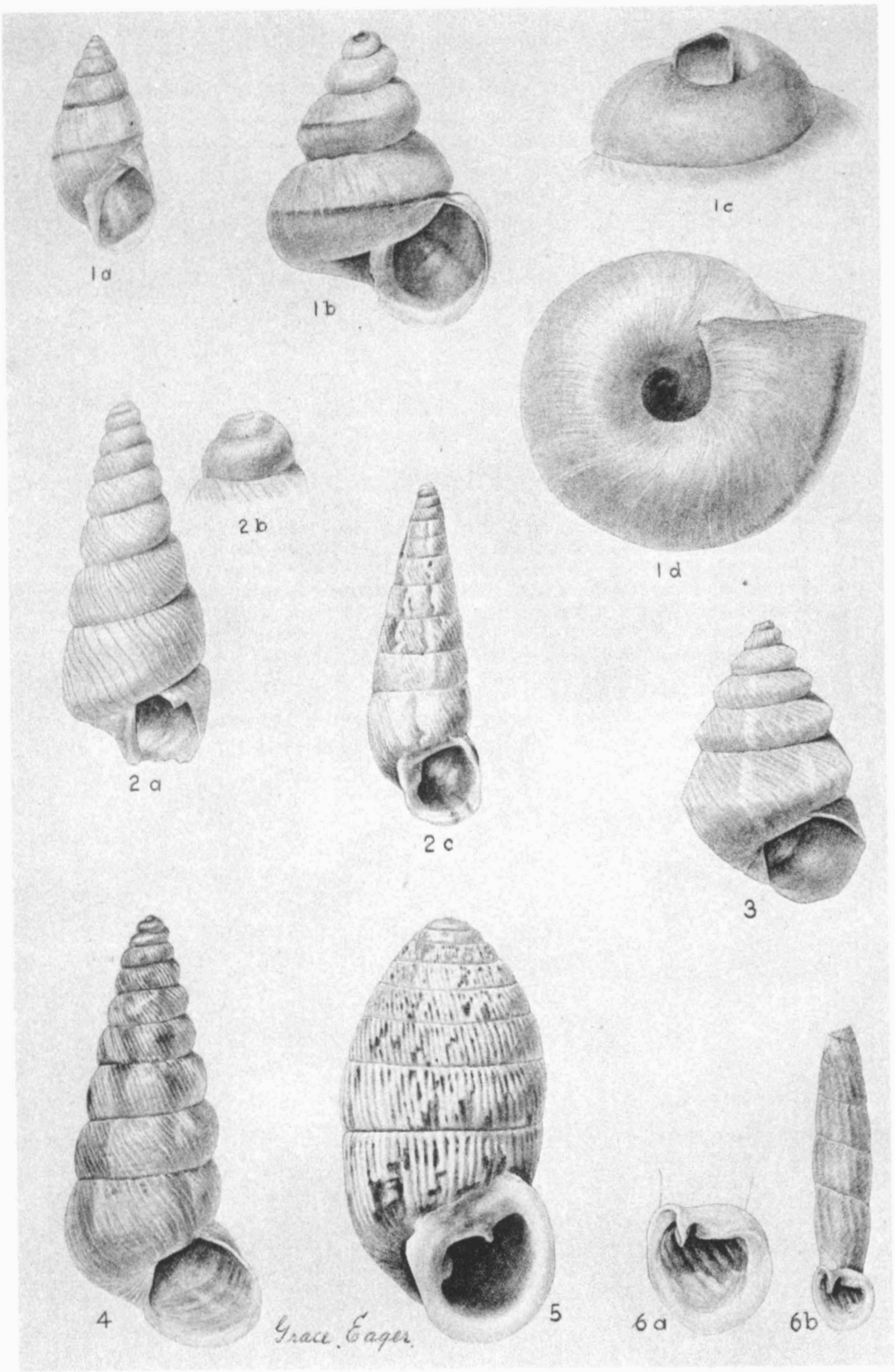
FIG. 3. *Pseudopineria viequensis* (Pfeiffer). Height, 4.7 mm.; width, 2.8 mm.

FIG. 4. *Microceramus guanicanus* H. B. Baker. Height, 7.0 mm.; width, 2.8 mm.

FIG. 5. *Cerion crassilabris* (''Shuttleworth'' Sowerby). Height, 19.4 mm.; width, 8.8 mm.

FIG. 6. *Nenia tridens* (Schweigger). Height, 27.0 mm.; width, 5.3 mm. *a.* Enlargement of aperture. *b.* Front view.

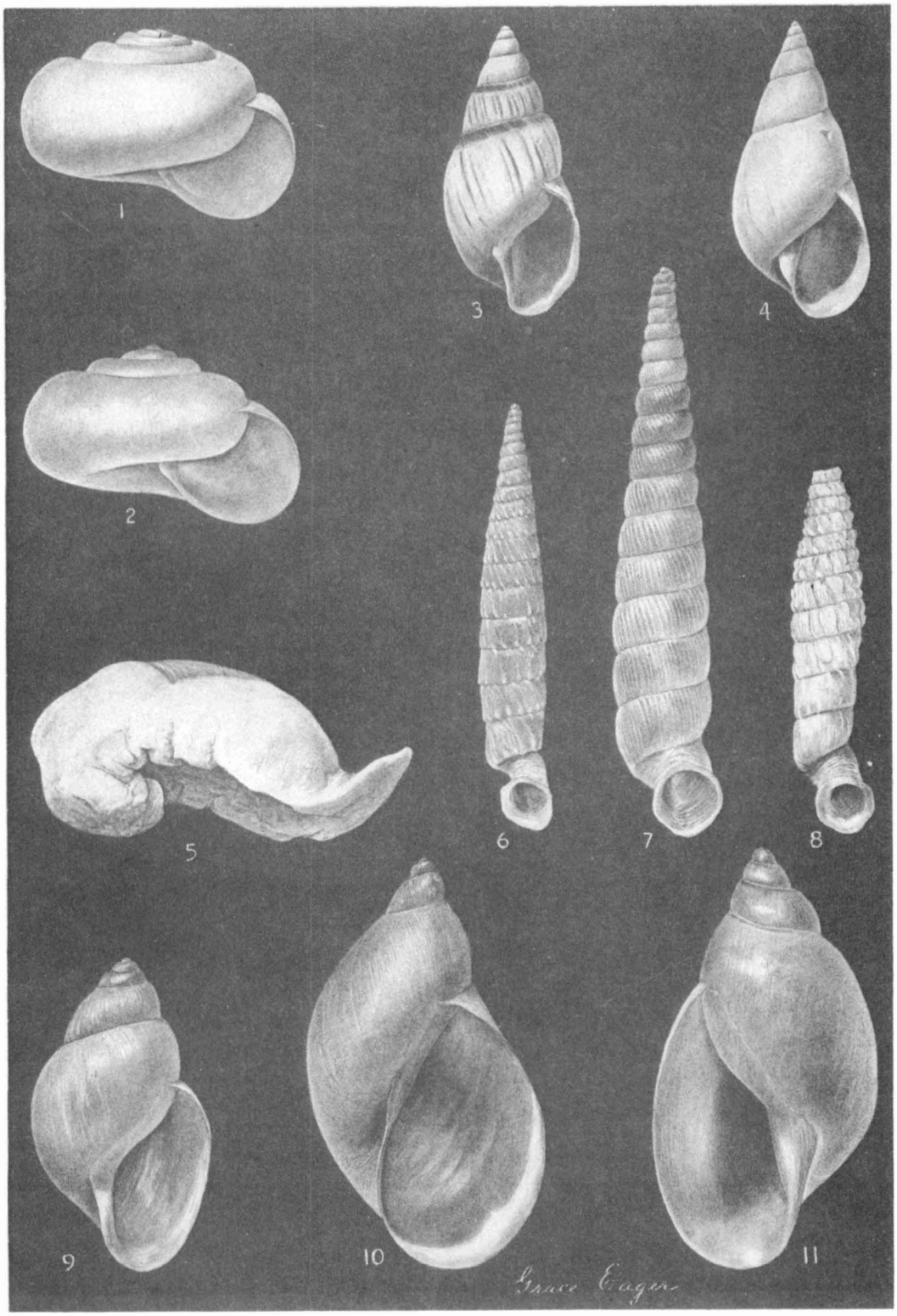
PLATE VII



## PLATE VIII

FIG. 1. *Aquebana velutina* (Lamarck). Height, 7.0 mm.; width, 12.9 mm.
FIG. 2. *Hyalosagda subaquila* (Shuttleworth). Height, 2.8 mm.; width, 4.7 mm.
FIG. 3. *Drymaeus virgulatus* (Férussac). Height, 26.0 mm.; width, 11.5 mm.
FIG. 4. *Drymaeus liliaceus* (Férussac). Height, 26.8 mm.; width, 11.8 mm.
FIG. 5. *Gaeotis nigrolineata* Shuttleworth. Height, 35.0 mm.; width, 14 mm.
FIG. 6. *Brachypodella riisei* (Pfeiffer). Height, 12.9 mm.; width, 2.0 mm.
FIG. 7. *Brachypodella portoricensis* (Pfeiffer). Height, 16.3 mm.; width, 2.8 mm.
FIG. 8. *Brachypodella pallida* (''Guilding'' Pfeiffer). Height, 11.3 mm.; width, 2.5 mm.
FIG. 9. *Lymnaea cubensis* Pfeiffer. Height, 7.6 mm.; width, 4.6 mm.
FIG. 10. *Lymnaea* (*Pseudosuccinea*) *columella* Say. Height, 10.3 mm.; width, 6.2 mm.
FIG. 11. *Physa cubensis* Pfeiffer. Height, 7.2 mm.; width, 4.9 mm.

PLATE VIII



## PLATE IX

FIG. 1. *Helisoma caribaeum* (D'Orbigny). Height, 7.5 mm.; width, 16.8 mm.
FIG. 2. *Helisoma terverianum* (D'Orbigny). Height, 2.3 mm.; width, 7.5 mm.
FIG. 3. *Tropicorbis riisei* (Dunker). Height, 2.0 mm.; width, 5.0 mm.
FIG. 4. *Tropicorbis albicans* (Pfeiffer). Height, 1.6 mm.; width, 5.3 mm.
FIG. 5. *Australorbis glabratus* (Say). Height, 7.0 mm.; width, 22.0 mm.
FIG. 6. *Tropicorbis decipiens* (C. B. Adams). Height, 0.9 mm.; width, 2.8 mm.
FIG. 7. *Pisidium* sp. Height, 2.5 mm.; width, 3.0 mm.
FIG. 8. *Drepanotrema anatinum* (D'Orbigny). Height, 1.0 mm.; width, 1.6 mm.
FIG. 9. *Uncancylus concentricus* (D'Orbigny). Height, 2.0 mm.; width, 5.3 mm.
FIG. 10. *Ferrissia beaui* (Bourguignat). Height, 0.7 mm.; width, 2.7 mm.
FIG. 11. *Potamopyrgus coronatus* (Pfeiffer). *a.* Smooth form: height, 3.3 mm.; width, 1.7 mm. *b.* Coronate form: height, 4.0 mm.; width, 2.2 mm.

PLATE IX

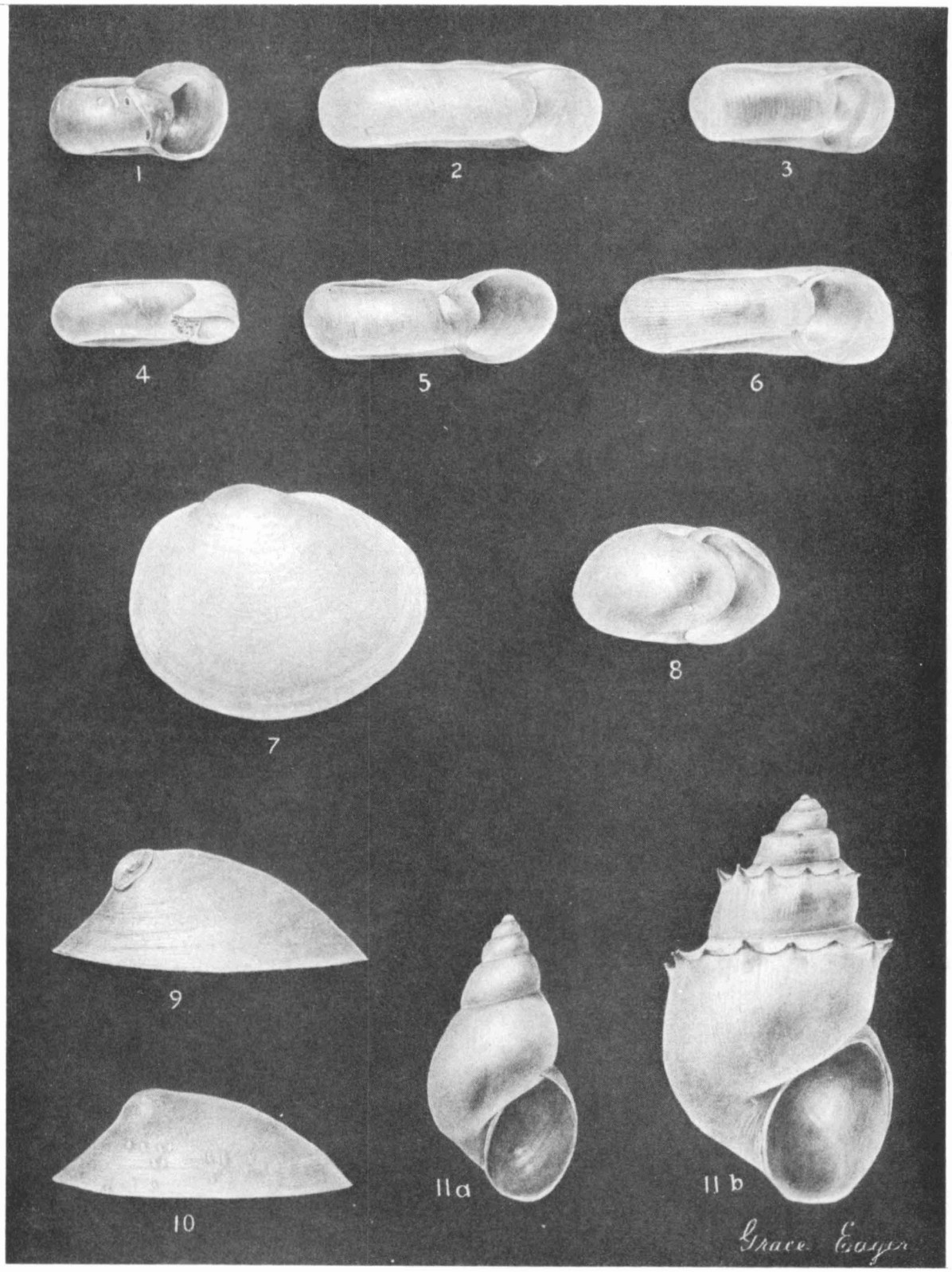


PLATE X

Variation in *Megalomastoma croceum* (Gmelin), illustrating a progressive increase in size from the higher elevations to the coastal plain.

The upper three specimens are from higher altitudes (length, 22, 25, and 26.5 mm.); the middle three are from the uplands (length, 28.5, 30.5, and 31.5 mm.); the lower three are from the coastal plain (length, 32.5, 34, and 35 mm.).

PLATE X

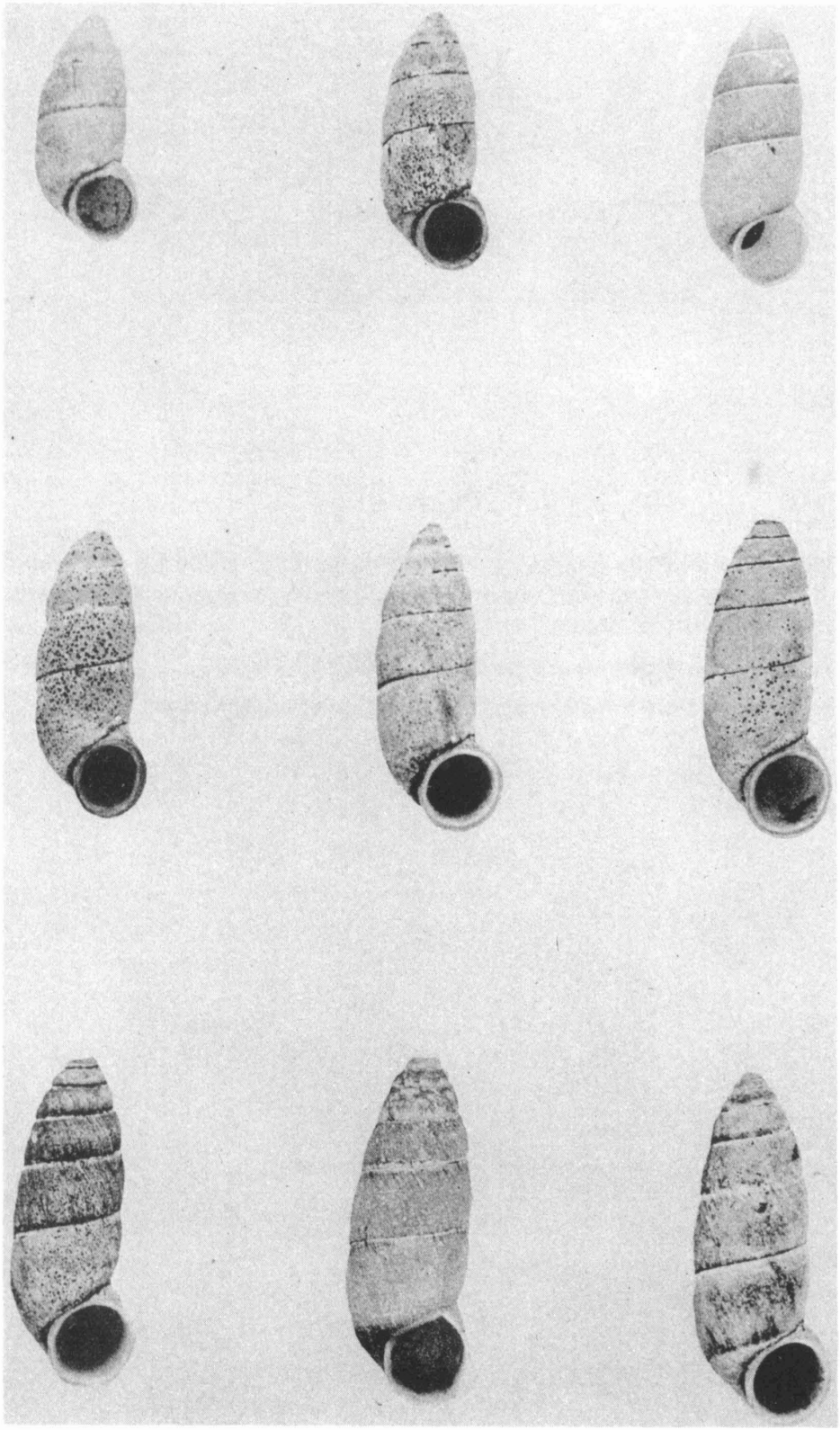


PLATE XI

Two views of the coastal plain of Puerto Rico showing the conditions which have been responsible for a considerable reduction and change of the original mollusk fauna.

FIG. 1. A coconut grove usually found on the alluvial plains.

FIG. 2. A view of the extensive region used for growing sugar cane.

PLATE XI

FIG. 1

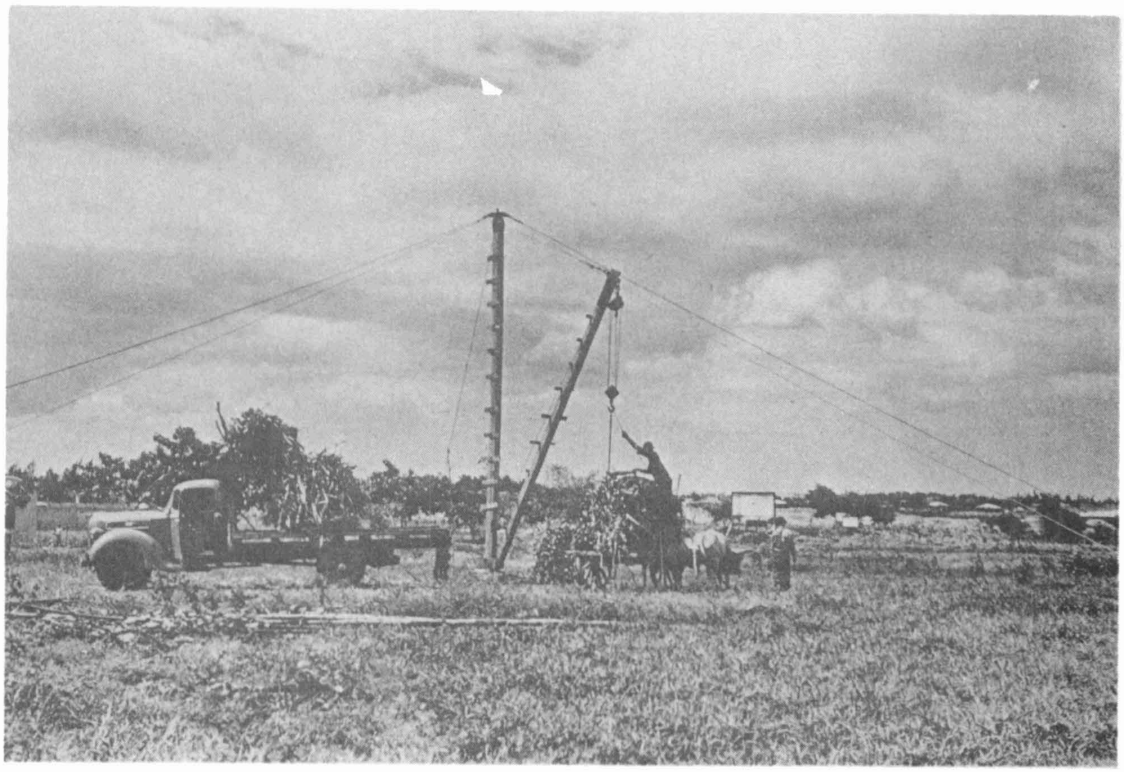


FIG. 2

PLATE XII

Two views across the upper peneplain of Puerto Rico.

FIG. 1. Extensive clearing of the wide plain as seen from foothills in the region of Aguas Buenas and looking south toward Cayey situated at the base of the Cordillera Central.

FIG. 2. A closer view of the upland hills to indicate the extent to which many of them have been cleared of vegetation.

PLATE XII

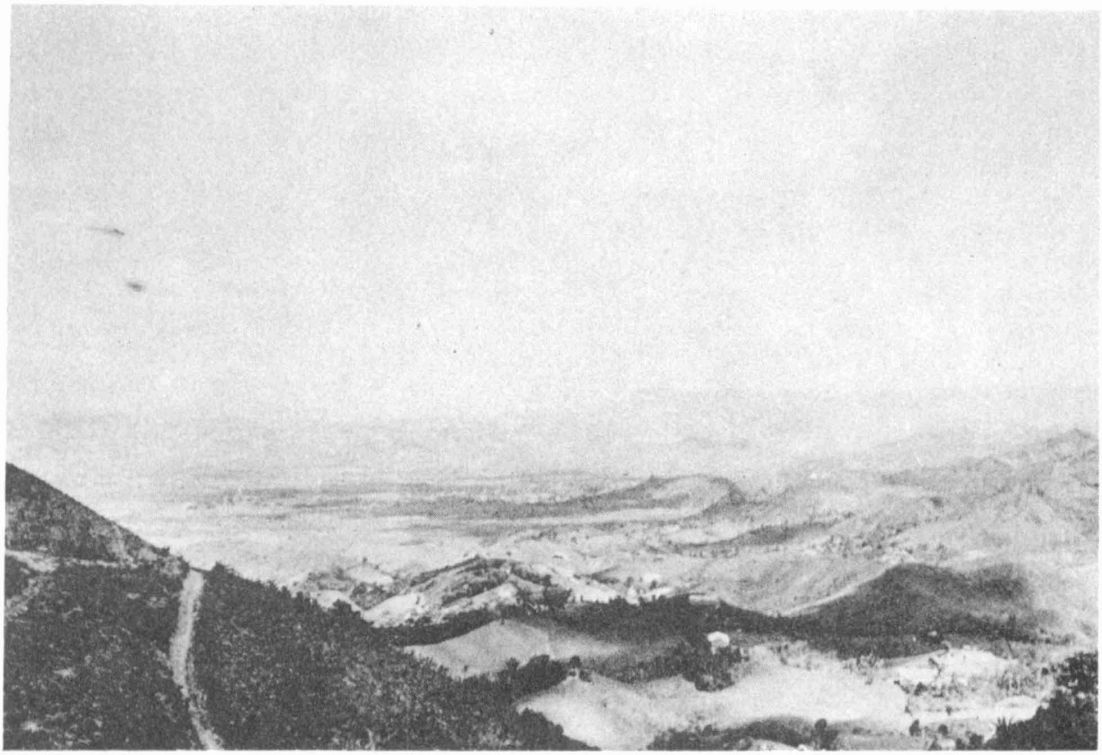


FIG. 1

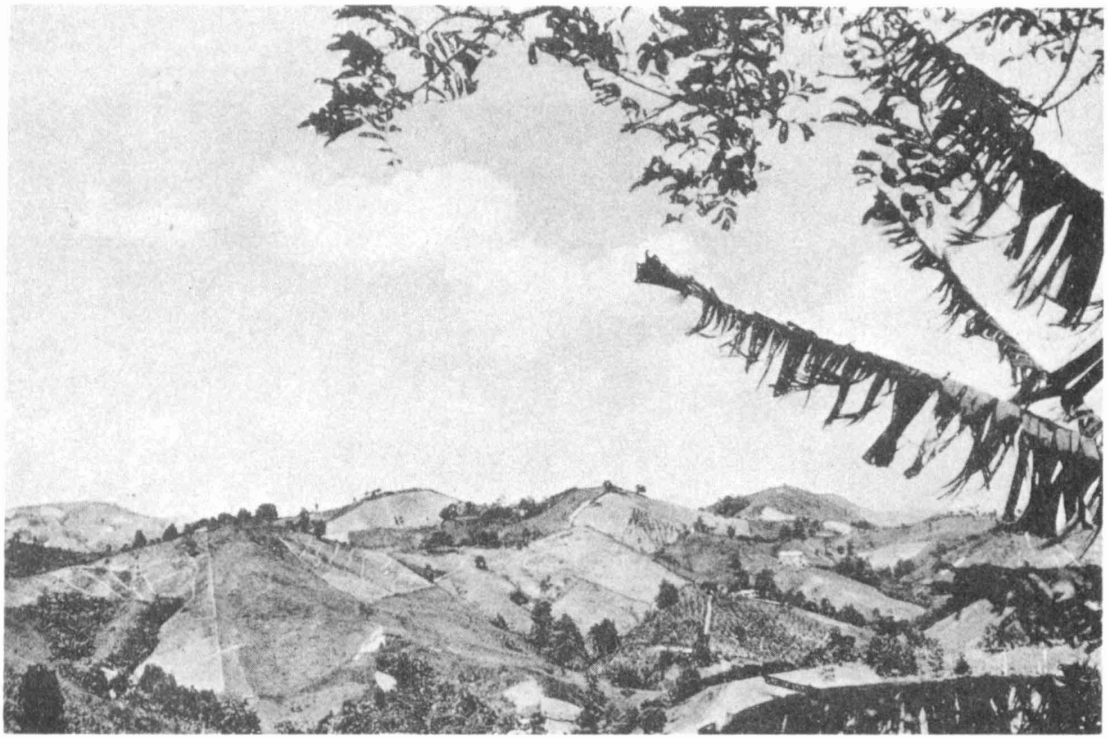


FIG. 2

## PLATE XIII

Scenes along river valley roads indicating the immense amount of clearing that has taken place.

FIG. 1. Abandoned farm land which is slowly beginning to develop a new ground cover.

FIG. 2. Poorly constructed houses along a river valley. The lack of sanitation in such homes helps to maintain a high incidence of diseases such as Schistosomiasis.

PLATE XIII

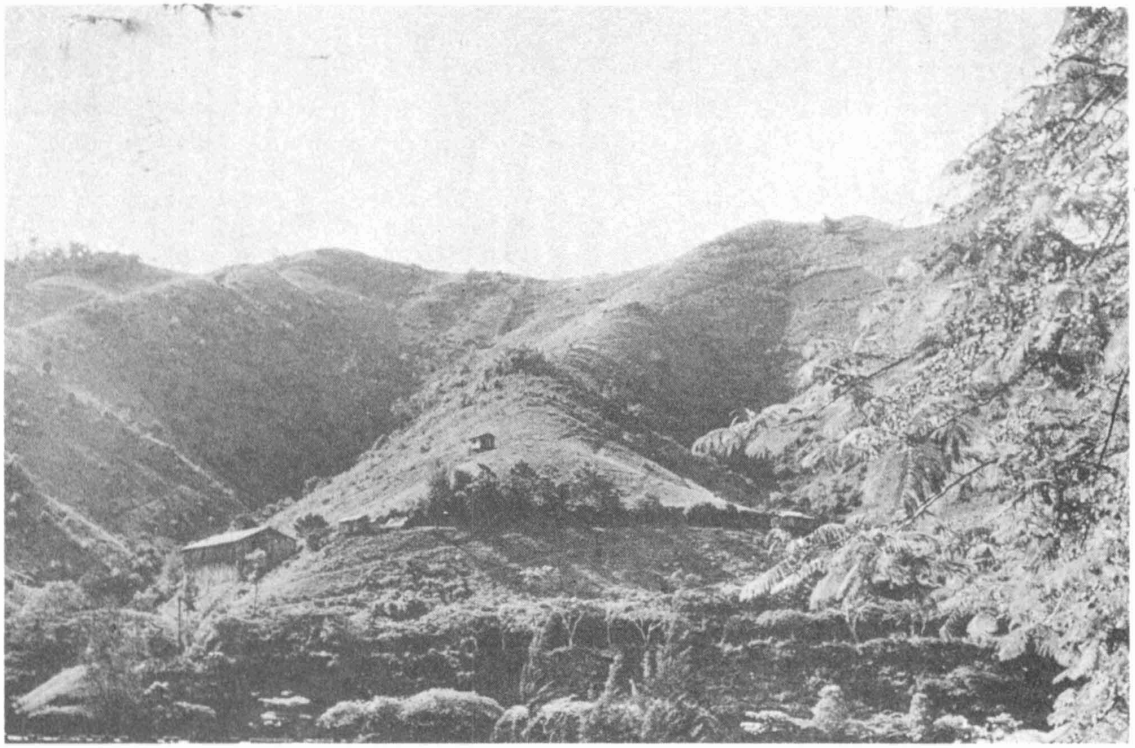


FIG. 1

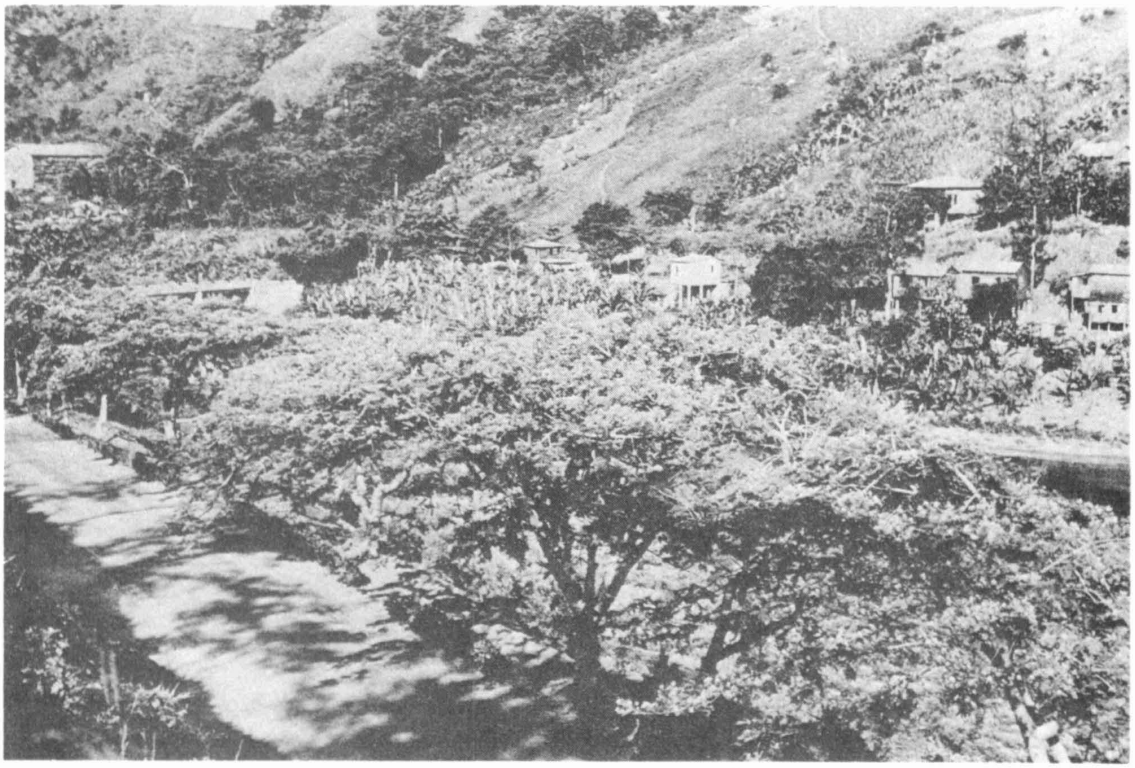


FIG. 2

## PLATE XIV

Two views of vegetative cover in which mollusk collecting was reasonably good.

FIG. 1. The type of upland forest in which coffee is grown. Such regions, if undisturbed, have sufficient moisture and vegetative cover to maintain snail populations.

FIG. 2. The karst topography of the extensive coastal plain west of Bayamon. These rugged limestone knolls are undisturbed by agriculture, and they harbor a large and characteristic mollusk fauna.

PLATE XIV

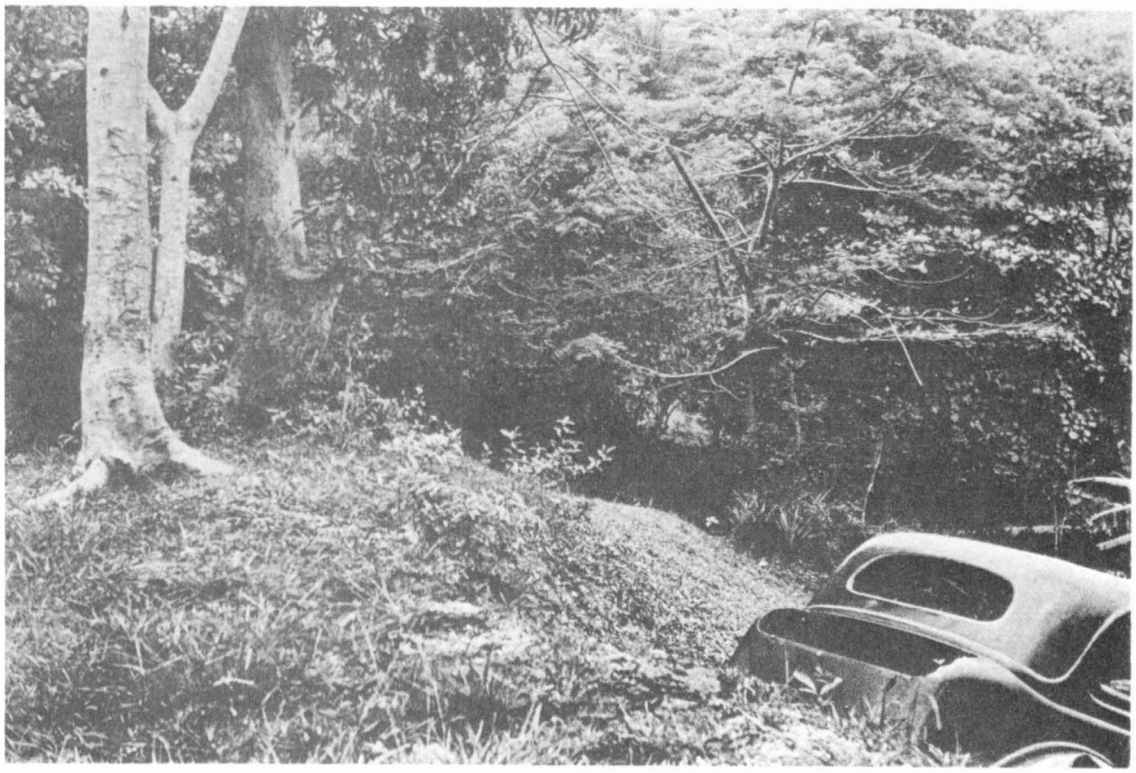


FIG. 1

FIG. 2

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